ICOM

Committee for Conservation, Madrid, 1972

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1/4

Rapport sur l'état actuel des recherches sur l'action de la lumière du jour sur pigments organiques des enluminures du moyen - âge.

présenté au groupe " Enluminures de manuscrits"
au Comité pour la Conservation de l'ICOM
Madrid, octobre 1972

H. Roosen-Runge

Afin de pouvoir étudier l'influence de la lumière du jour sur des pigments organiques d'enluminures du haut moyen-âge j'ai choisi le procédé qui suit:

1.Préparation de modèles peints avec les pigments choisis.

2.Passer ces modèles peints à un premier examen spectral-photométrique, appareil régistrant automatiquement Zeiss DMR 21. Ces examens ont été faits sous la direction de M.F.Czygan dans son Institut de Pharmacognosie de l'Université de Würzburg.

3.Exposition des modèles pendant un certain temps déterminé à la lumière du jour en mesurant la quantité de la lumière tombant dessus avec un Luxmeter automatique à cellule sélénifère. Cette exposition et les mesurages ont eu lieu dans l'Institut de Botanique II de l'Université de Würzburg sous la direction de M.O.L.Lange par M.L.Kappen.

4.Passer les modèles à un second examen spectral-photométrique. Ces examens ont été faits comme sous 2.

5.Comparer et commenter les courbes de no.2 et 4.

1.Parmi les pigments organiques,nommées dans les traités du haut moyen-âge, j'ai choisi ceux qui me semblaient les plus délicats, c.a.d. folium, indicum, succus porri, succus gladioli, succus caulae, crocus, sanguis draconis, bresilium, kermes (cru), kermes-carmin (préparé à l'alum), kermes-vermiculum (préparé au citron ou au vinaigre).
J'avais espéré pouvoir présenter des modèles de ces pigments peints au pinceau sur parchemin à la spectral-photométrie mais les premiers résultats montrèrent que le parchmin absorba beaucoup trop de la lumière traversante pour pouvoir acquérir des diagrammes lisibles. Or, j'ai fait d'autres modèles de pigments sur verre et j'ai préparé 61 modèles de différente épaisseur et avec des quantités variées de clarea comme liant.

2.Le premier examen spectral-photométrique qui nous donna 61 diagrammes (voyez l'annexe) fut fait entre le 4.4.72 et le 27.4.72. Aussitôt après les mesurages les modèles ont été remis dans l'obscurité absolue d'une boîte jusqu'au 12 mai.

3.A partir de ce jour, 12.mai, jusqu'au 2o juillet ils ont été exposés à l'Institut Botanique dans une pièce donnant à l'est. Nous avons bien pris soin de ne jamais laisser entrer le soleil direct dans cette pièce pour que les conditions d'expositions soient aussi semblables que possible à celles d'une salle de bibliothèque ou de musée ouverte du matin 8^h jusque vers 18^h où on fermait les volets sans alumer la lumière électrique. Vers 21^h un contrôleur visita chaque soir le lieu en allumant pour peu de temps la lumière électrique. Sur un fond de parchemin les modèles peints sur verre ont été groupés directement autour du Luxmeter à cellule sélénifère et muni d'un verre opal. Le Luxmeter mesura toutes les lo minutes la quantité de lumière en préparant un diagramme(une courbe) très étendu. L'évaluation de ces valeurs sera faite plus tard.

4.Le 8.août fut fait la seconde série de diagrammes spectral-photometriques. Les courbes se trouvent sur les mêmes feuilles que celles des premiers mesurages. L'intensité des couleurs a été mesurée cette seconde fois à la même place des modèles qui avait été examinée la première fois.

5.Sur les 31 feuilles qui suivent ce rapport on trouve les 61 diagrammes correspondant aux 61 modèles de pigments passés à l'examen spectral-photometrique. Les numéros des diagrammes corresponde à ceux des modèles peints sur verre et nommés dans la liste "Beleuchtungsversuche mittelalterlicher Farbstoffe".

La coordannée verticale indique le degré de transmission de la couche du modèle peint envers la lumière, zero enhaut le minimum, loo enbas le maximum. La distance plus ou moins grande entre deux courbes comparables signifie donc un changement de transmission plus ou moins grand. Le relèvement vers le haut indique une diminuation de transmission, l'abaissement vers le bas correspond à une augmentation de la transmission. La coordannée horizontale suit de gauche à droite l'ordre du spectre.Toutes les

courbes sont datées. Parfois il y en a plus que deux pour un [illegible] parchemin, considérant le degré de la transmission des couleurs on a été obligé de rechercher pour la première courbe la moitié intensité de la transmission. Ces valeurs ont été indiquées à gauche des courbes (o - 1oo, o -5o, o - 2o, o - 1o).
Les diagrammes ci-joints sont le résultat d'un premier examen et ne donnent pas encore de certitude statistique. En aucun cas on peut en tirer des conclusions définitives. Néanmoins on peut déjà constater que les couleurs que nous avons exposées pendant 7o jours ont éprouvé des changements.

Nous comptons continuer cette série d'expériments. Les mêmes modèles de pigments seront encore exposés plusieurs fois à la lumière du jour pour savoir à quel point une exposition perpétuée influence les couleurs. D'autres séries seront faites pour les exposer à des lumières artificielles. En outre il nous tarde de rechercher à quel point, hors la lumière, d'autres causes comme par exemple l'oxygène de l'air ont contribué au changement de la qualité des couleurs. Nous peindrons 2 séries de modèles pour en exposer une à la lumière du jour, l'autre en même temps sans lumière uniquement à l'oxygène de l'air et pour constater les deux effets.

Enfin nous sommes spécialement interessés à rechercher par une série d'expériments analogues quelle est la dose de lumière du jour (ou artificielle) supportable par les couleurs organiques des anciennes enluminures sans un effet nuisible. Dans l'ensemble de ces questions il sera util de se rendre compte des effets des différents filtres dont parle le rapport "Products and Instruments suitable for use in Museums for protection against damage by light" du groupe de travail "Eclairage" de notre comité, distribué au congrès 1969.

Crocus pomum, dick aufgetragen
" " , weniger "
" " " "
" " , dünn "

" " m. Überzug v. Clarea
" wie 3, weniger dick aufgetragen
" wie 3 " "
" wie 4 dünn "

[illegible] cum cochenilla et calce viva, dick aufgetragen
" " , weniger "
" " , " "
" " , dünn "

" " , mit Überzug v. Clarea
" " , wie 10 weniger dick aufgetragen
" " , wie 11 "
" " , wie 12, dünn "

Blum mit Clarea gemischt, dick aufgetragen
" " , weniger "
" " , dünn "

Cum purp " , Degast 1905, d, mit Wegmal aus d. Prigort geleit

Minium, Bergzeln, Stern Apoth. Augsburg, dick aufgetragen, mit Clarea angemischt
" " , dünn " "

Cum porri, dick aufgetragen
" , dünn "

[illegible], dick "
" , dünn "

[illegible], (dick) " (aufgeschichtet zusammengezogen)
" , dünn "

29. Crocus pomum, dick aufgetragen
30. " " , weniger "
31. " " , dünn "

32 " c. clarea, dick "
33 " " , dünn "

34. Sanguis draconis, c. clarea, dick aufgetragen
35. " " , dünn "

36. " , c. lithglycerolla, dicke "
37. " " , dünn "

38. " , c. gummi, dicke "
39. " " , dünn "

40. Brasilium, Haraclius III, XXXIV, a, in patella aerea, dick aufgetragen, m. Clarea vermischt
41. " " weniger dick " "
42. " " dünn "

43. " b, in Porzellanschale, dick " "
44. " " , wie 41 " "
45. " " wie 42 " "

46. Kermes, roh, dick aufgetragen
47 " " , dünn "

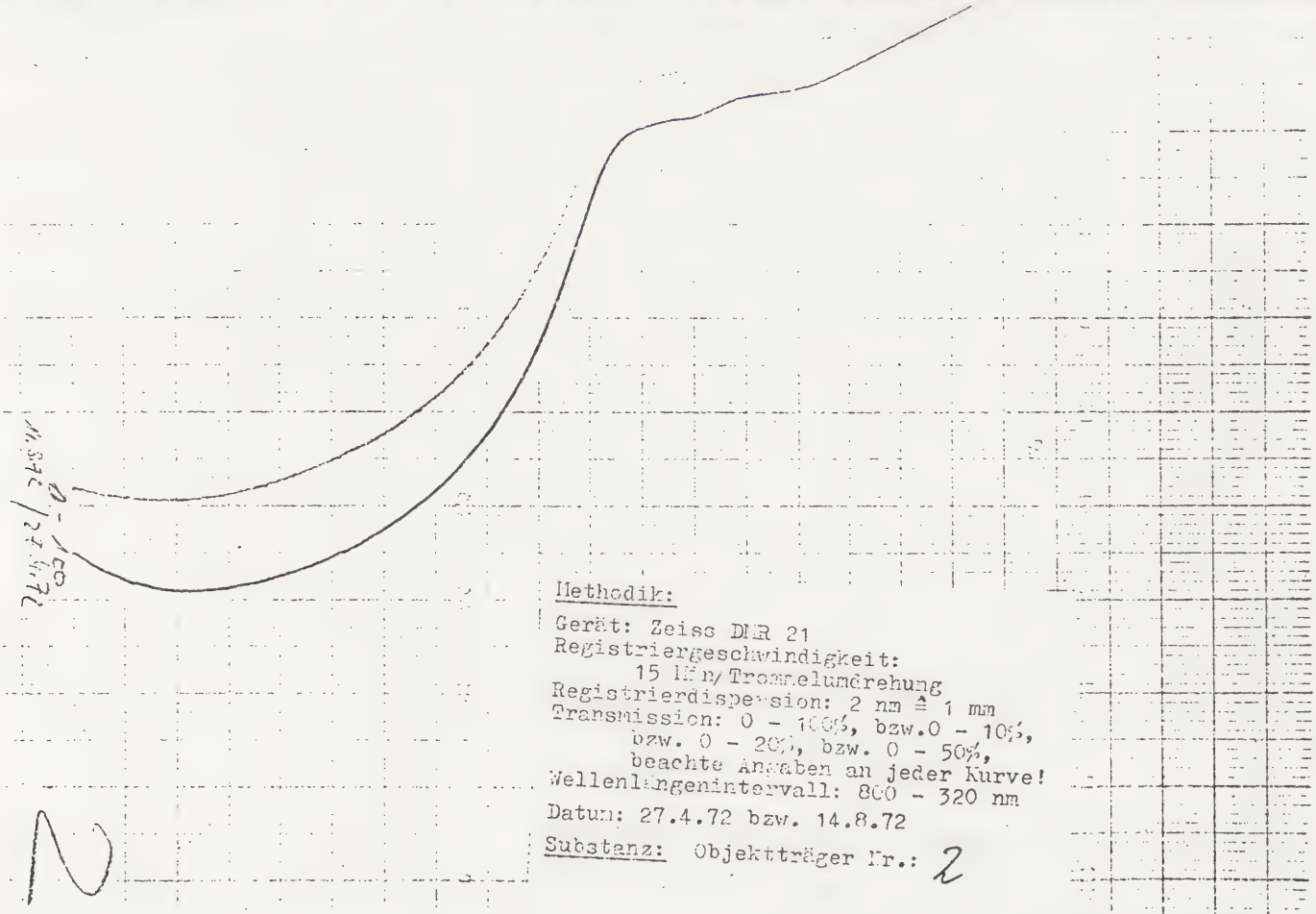
48. Kermes + alumen (carmin), hoher Blum-Anteil (mehr als angegeben), dicke aufgetragen, m. Clarea vermischt
49. " " weniger dick " "
50. " " dünn " "
51. " " " " "

52. " (carmin) geringer alumen-Anteil (angegeben), mit mehr Clarea vermischt, dicke aufgetragen
53. " " " " " weniger dick
54. " " " " " , m. wenig Clarea
55. " " " " " , m. mehr Clarea
56. " " " " " , dünn "

(Gelbstimmungsbarometer mit [illegible])

57. Körnerlack-Saft (Vermiculum), mit geringem Claro Anteil vermalt, dicke aufgetragen
58. " " , " , dünn "
59. " " , hohem " , dicke "

60. " acetum (Vermiculum), mit Claro vermalt, dicke "
61. " " " " " , dünn "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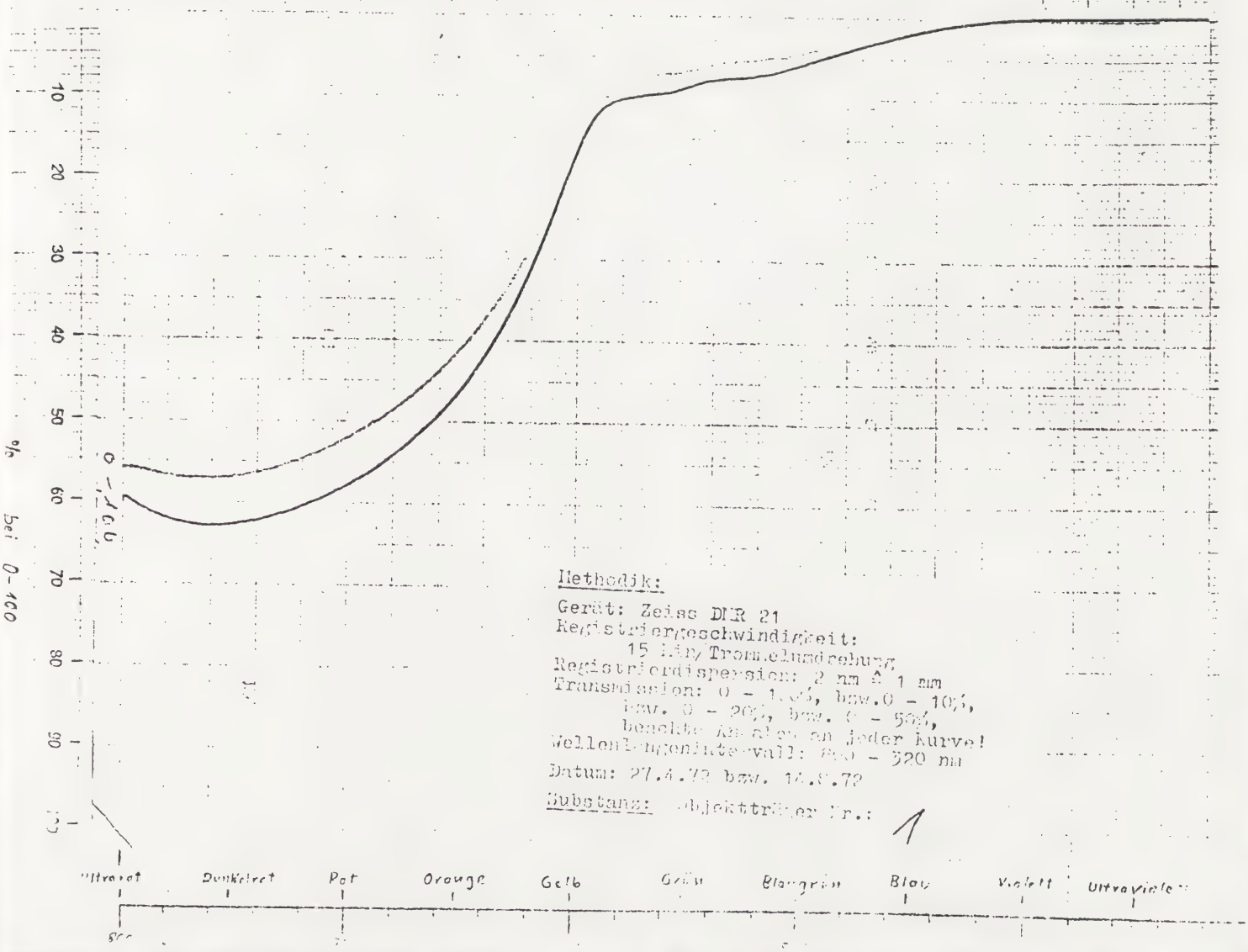
10
20
30
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% bei 0-100
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bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
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Ultrarot
Dunkelrot
Rot
Orange
Gelb
Grün
Blaugrün
Blau
Violett
Ultraviolett

Methodik:

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bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
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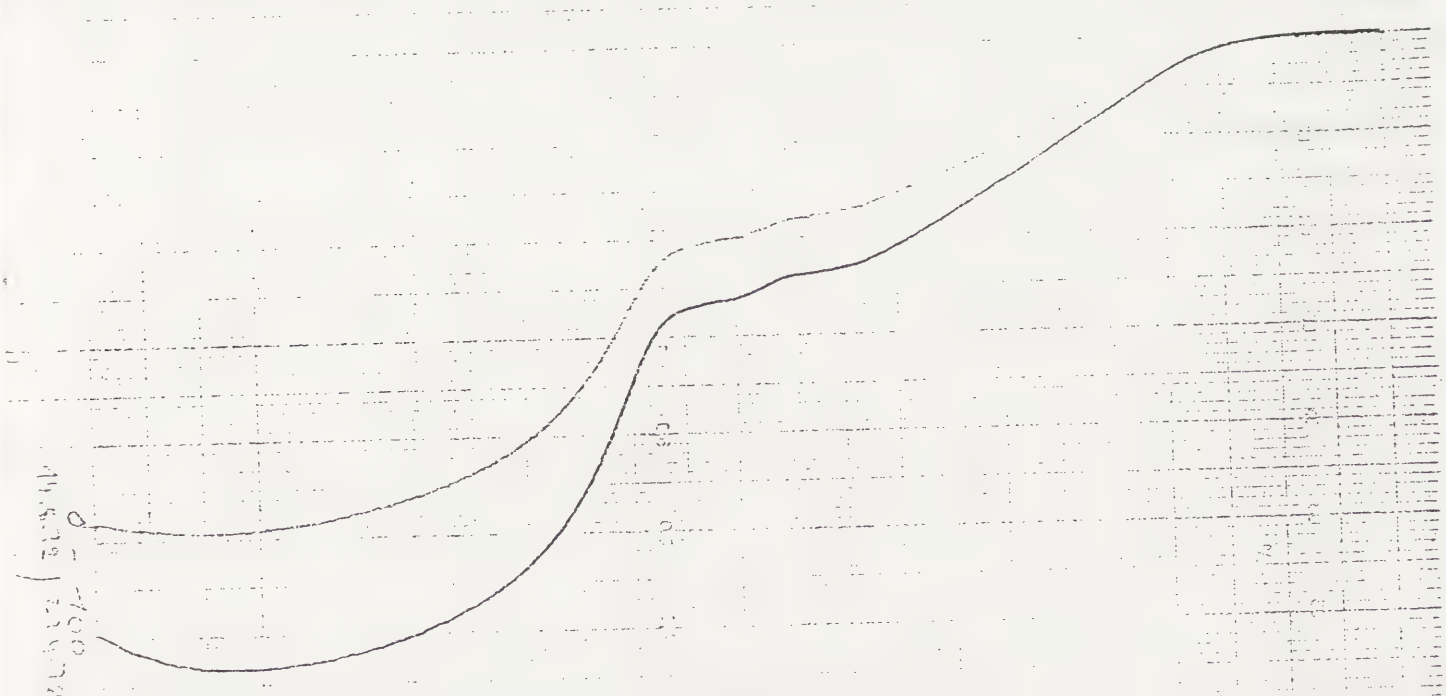
Datum: 27.4.72 bzw. 14.8.72

Substanz: Objektträger Nr.: 4



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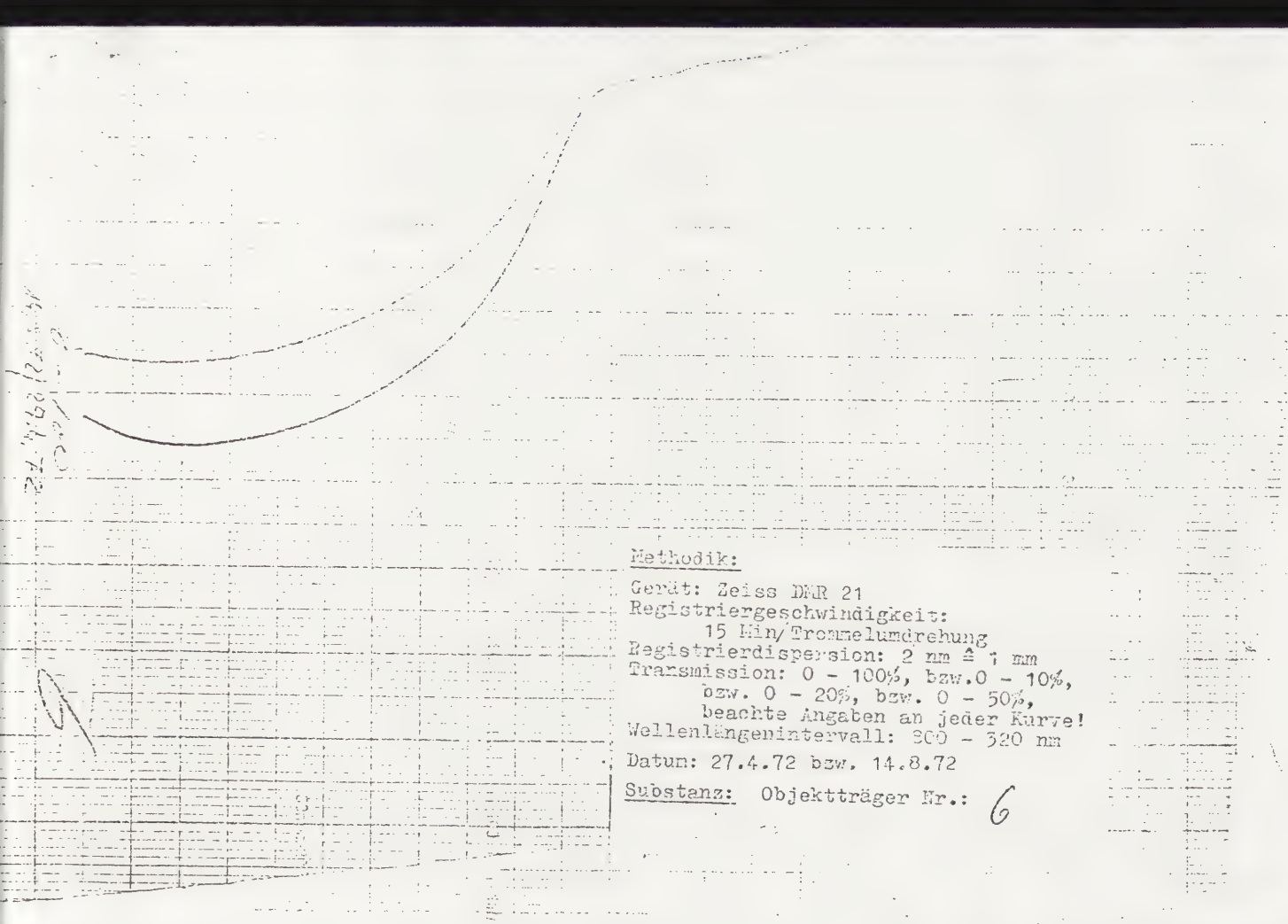

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beachte Angaben an jeder Kurve!
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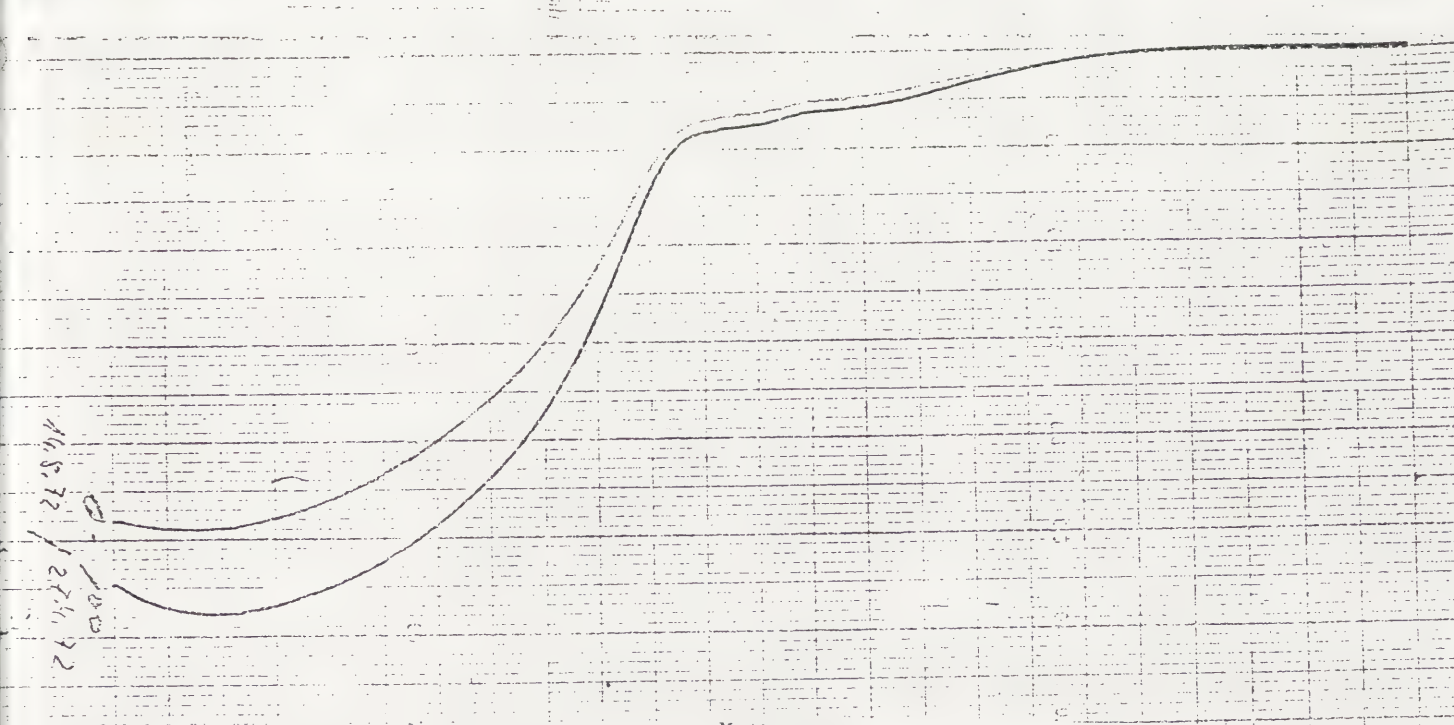

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beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

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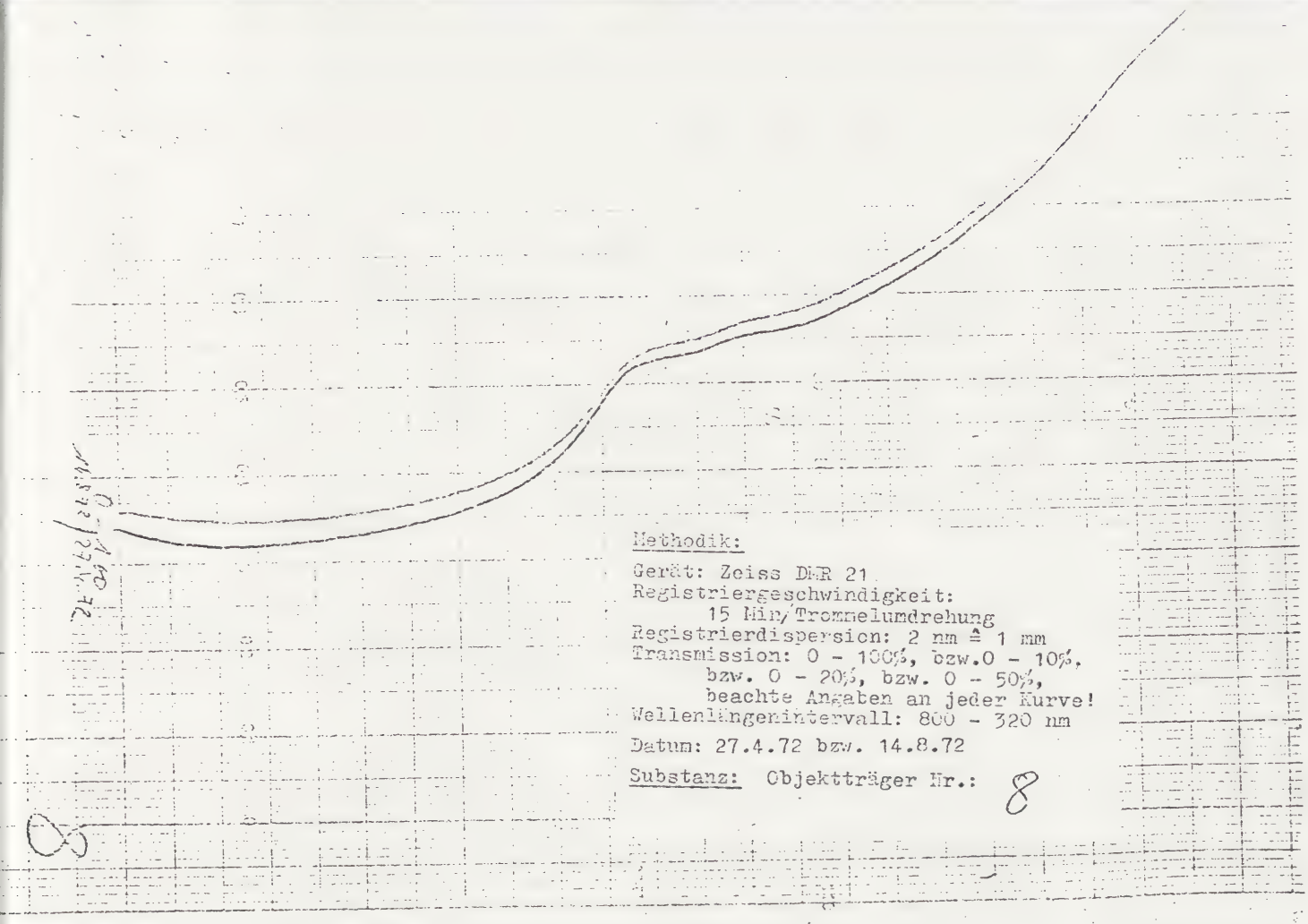
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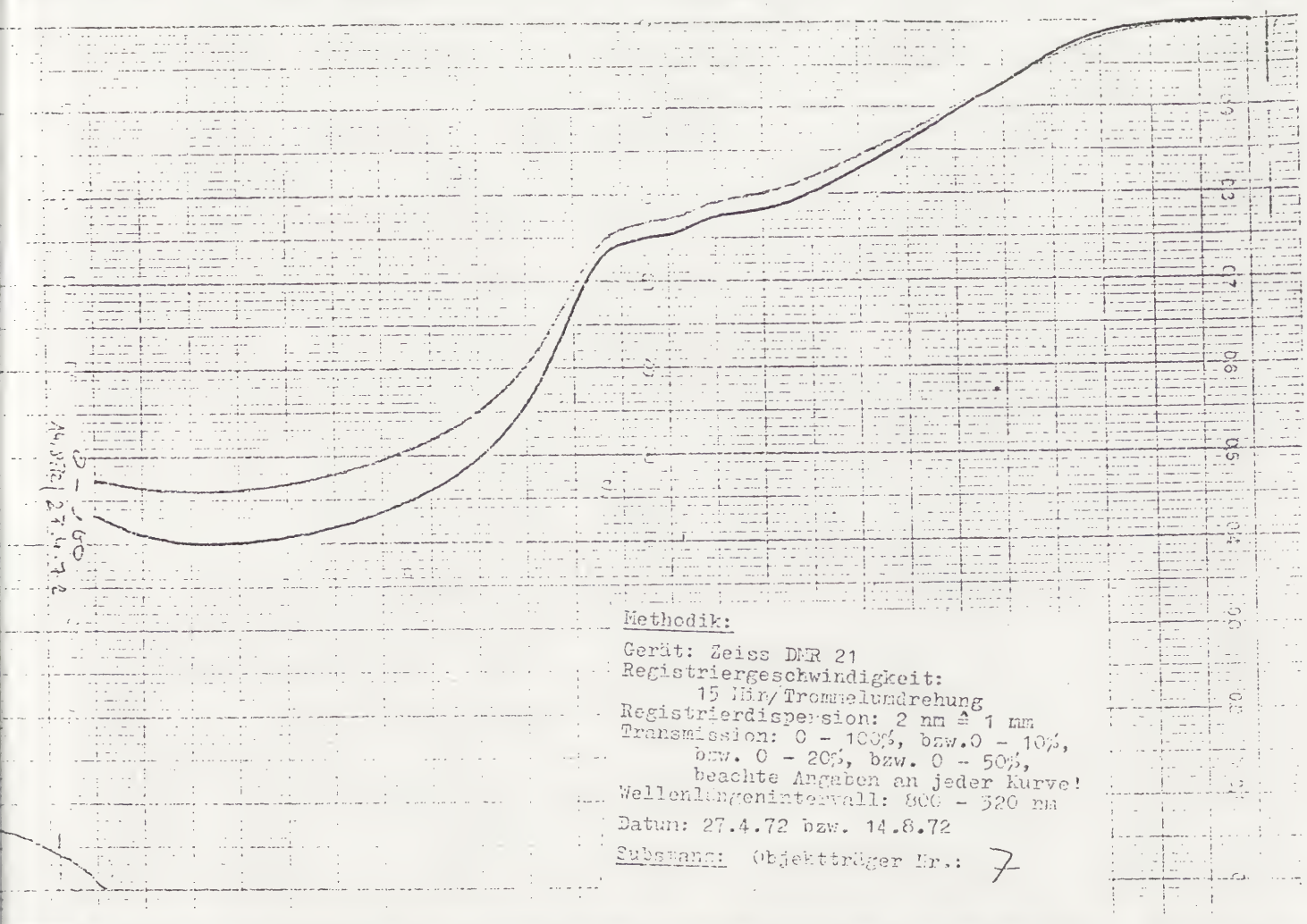
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bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
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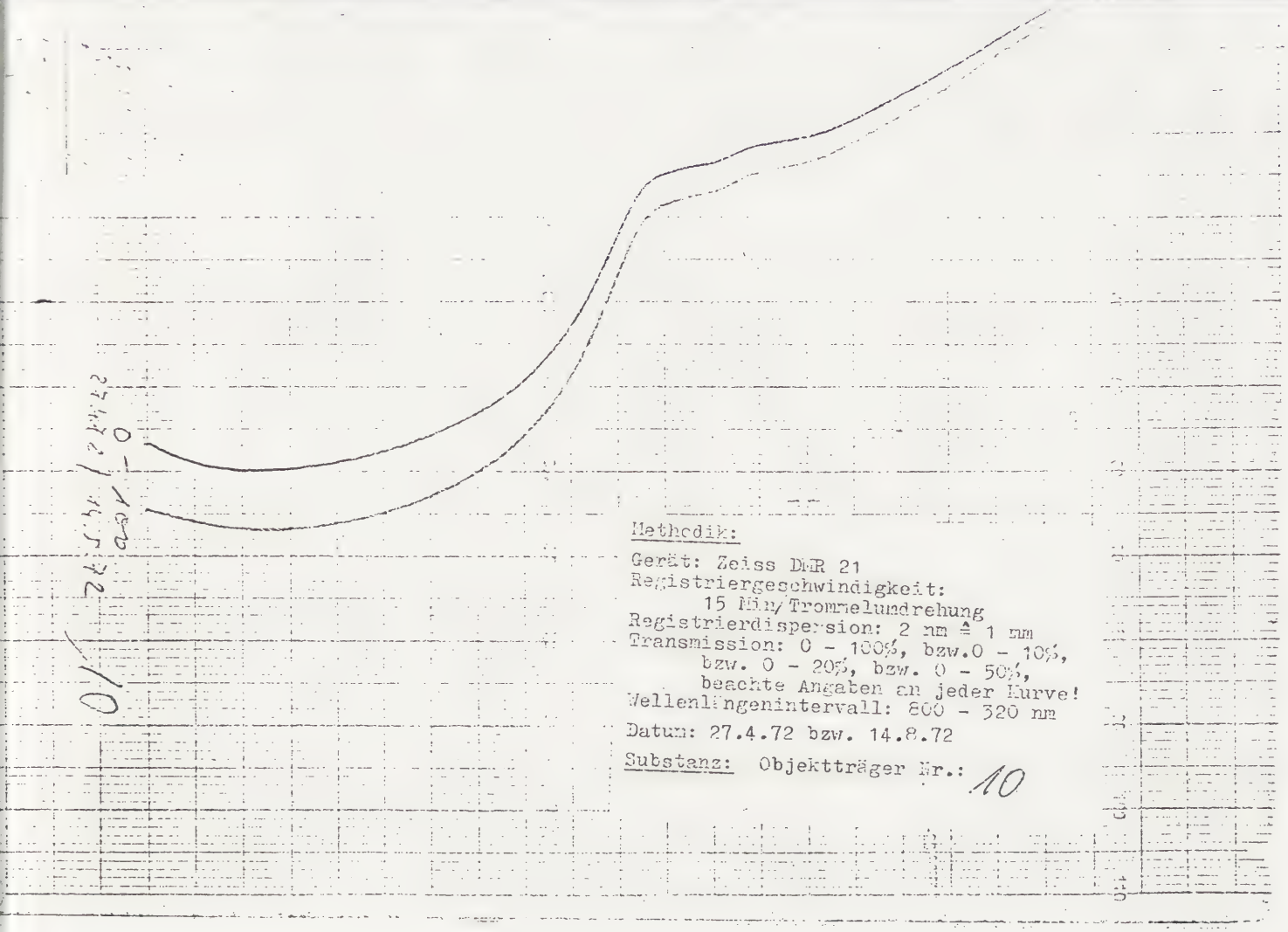
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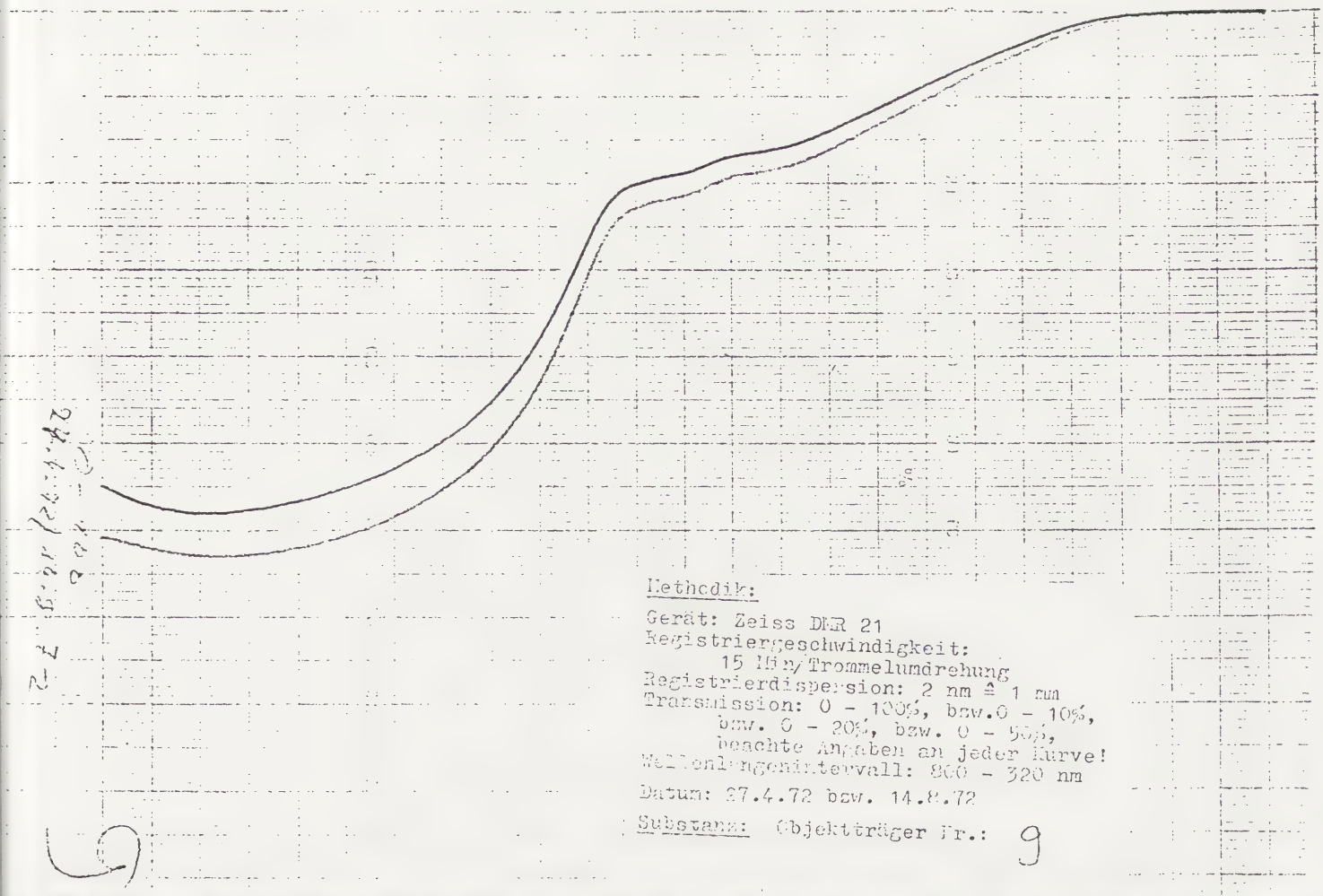
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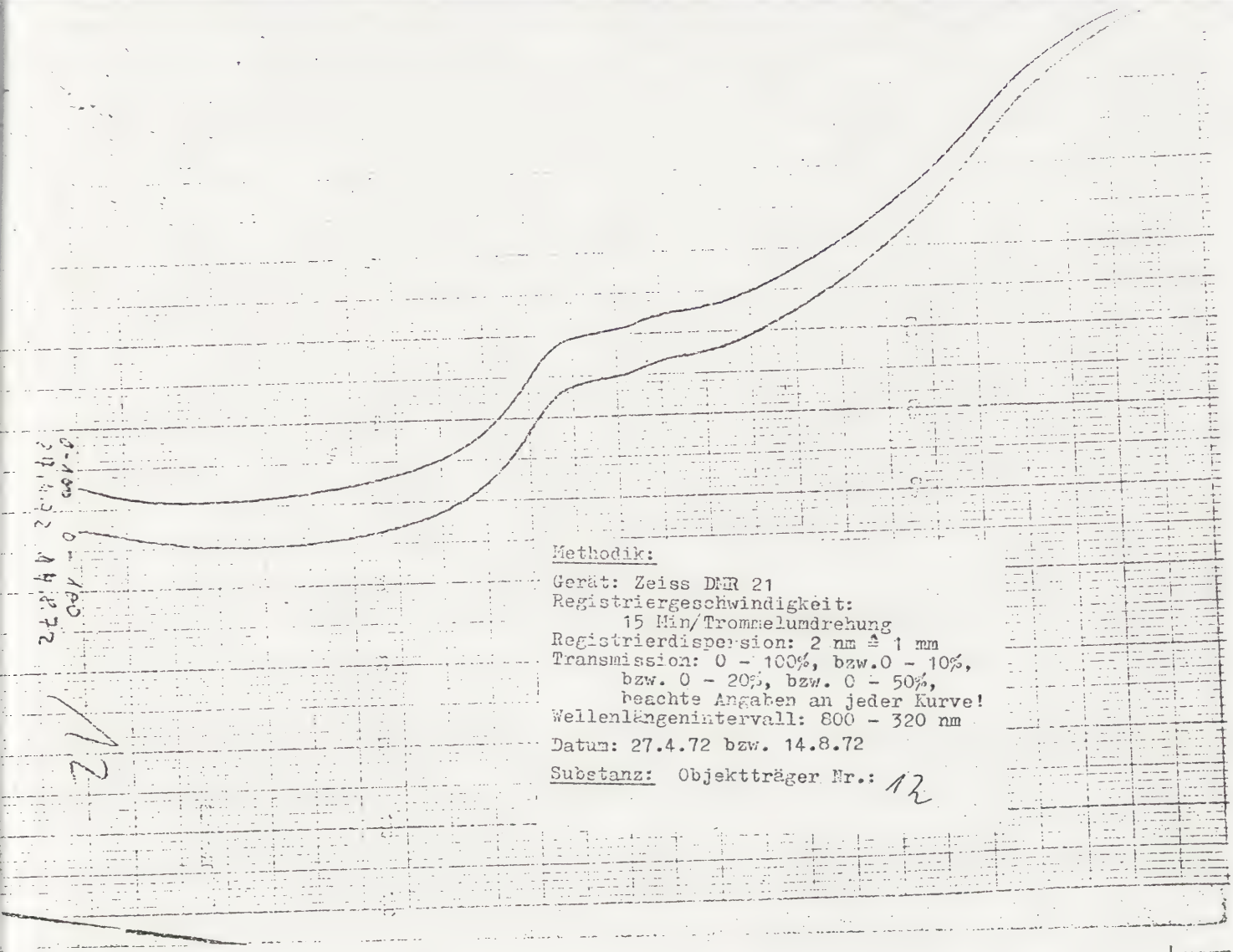

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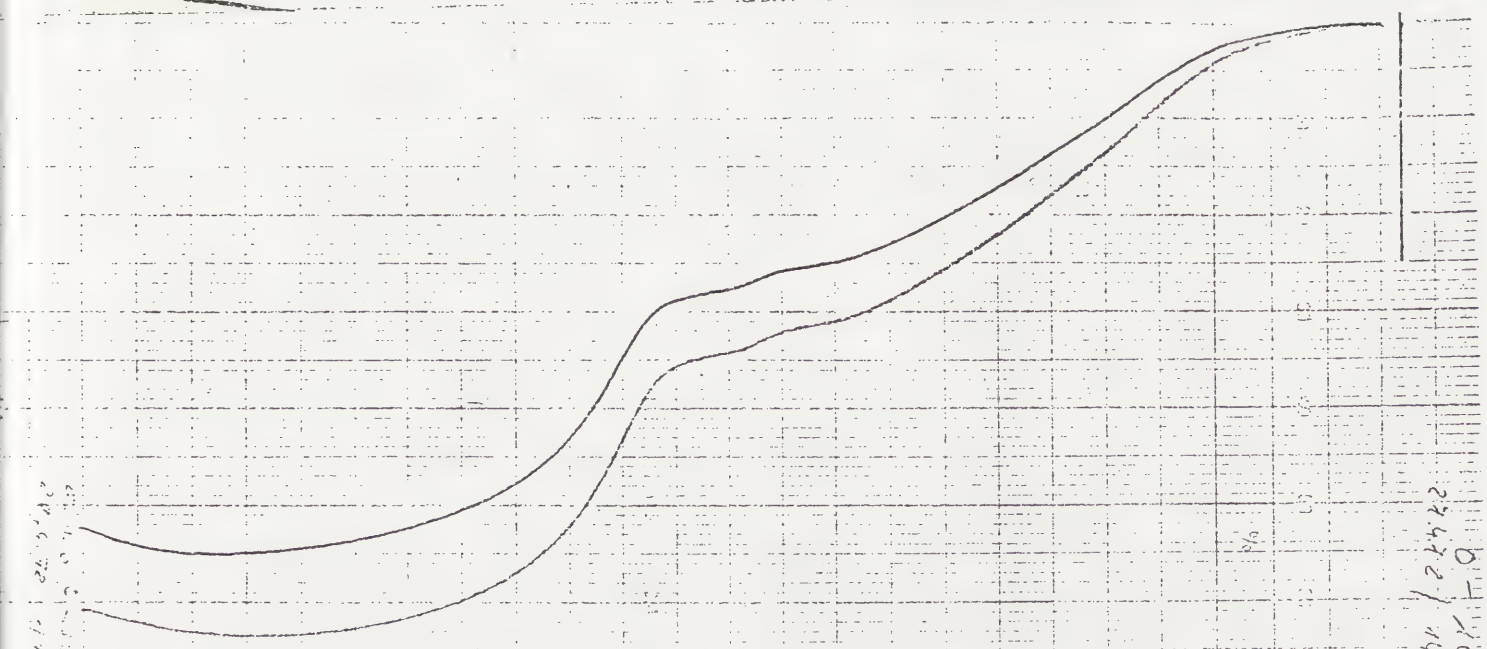

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beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

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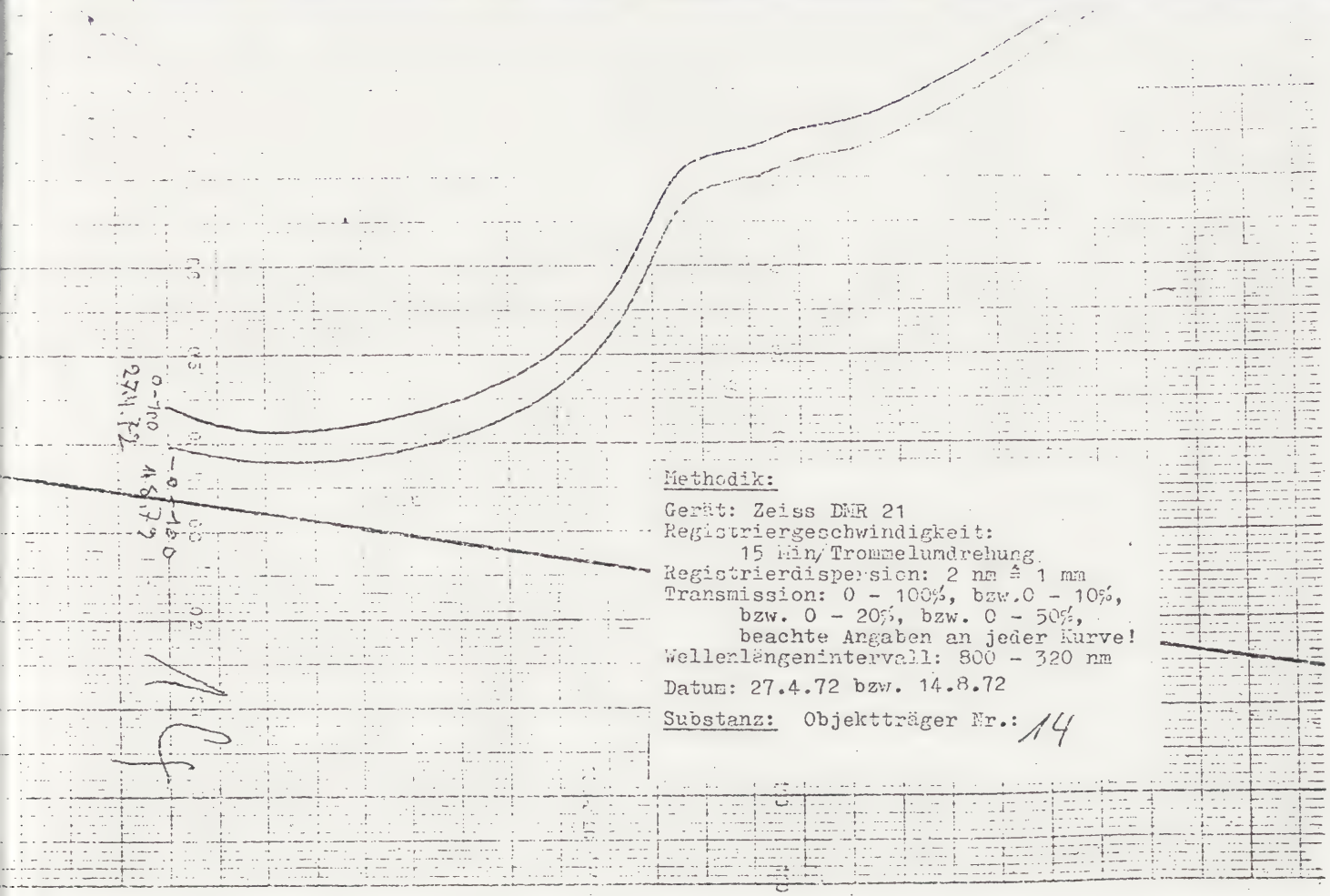

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bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

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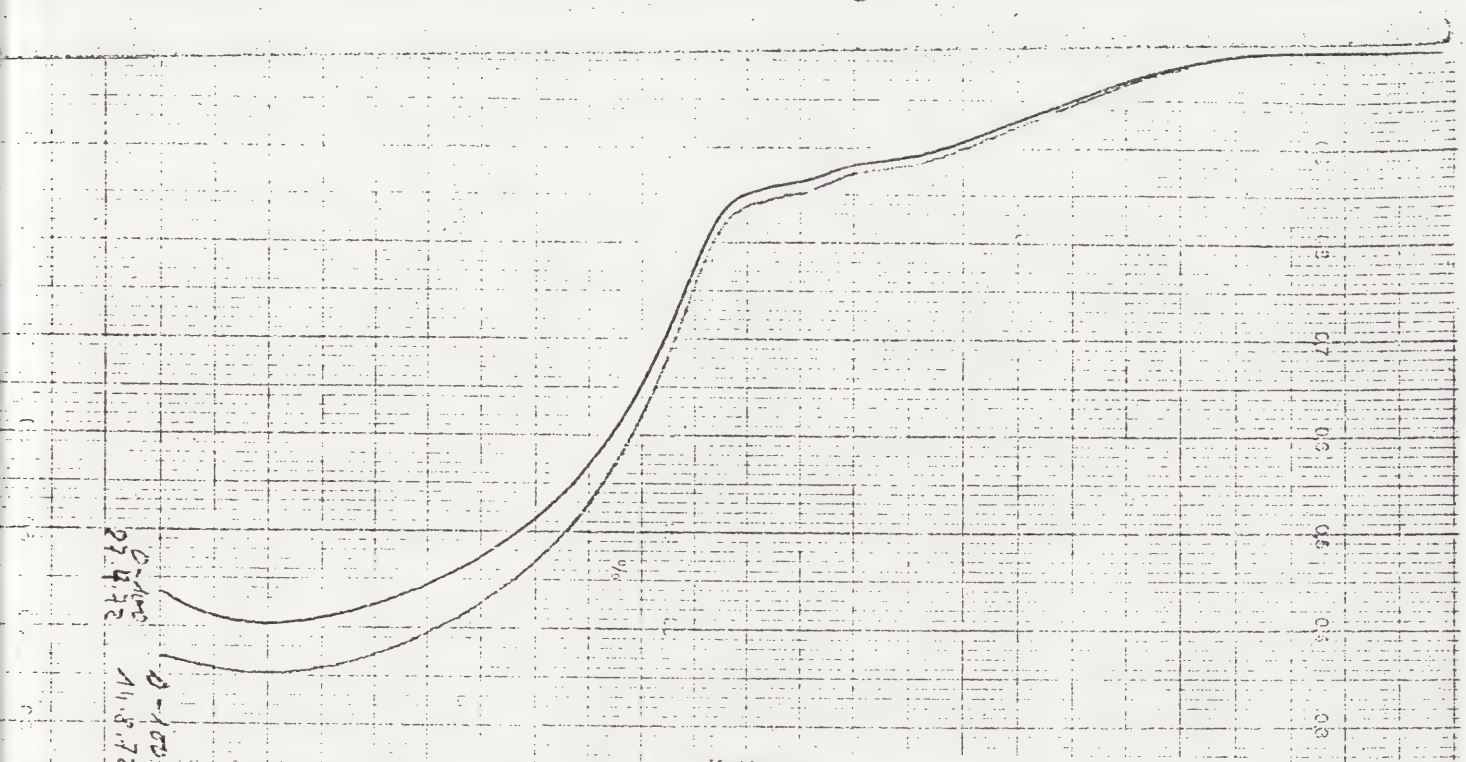

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bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

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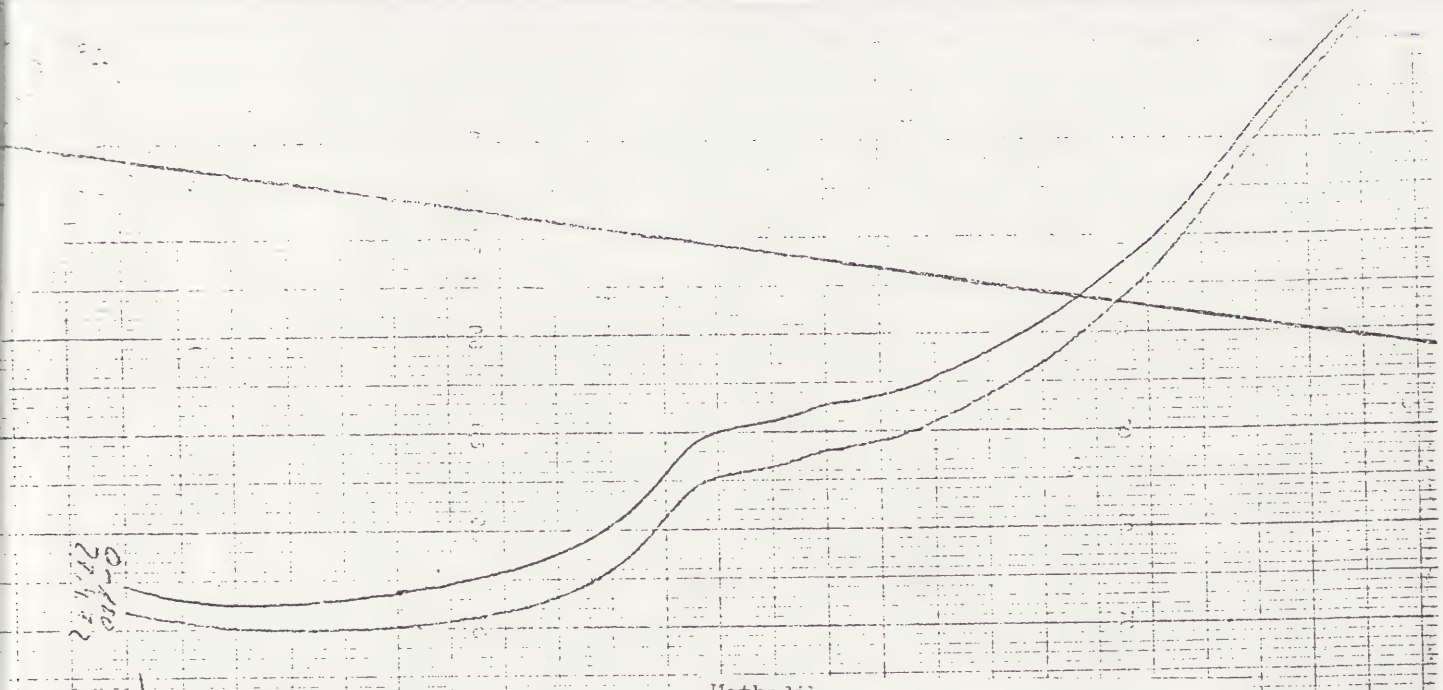

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bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

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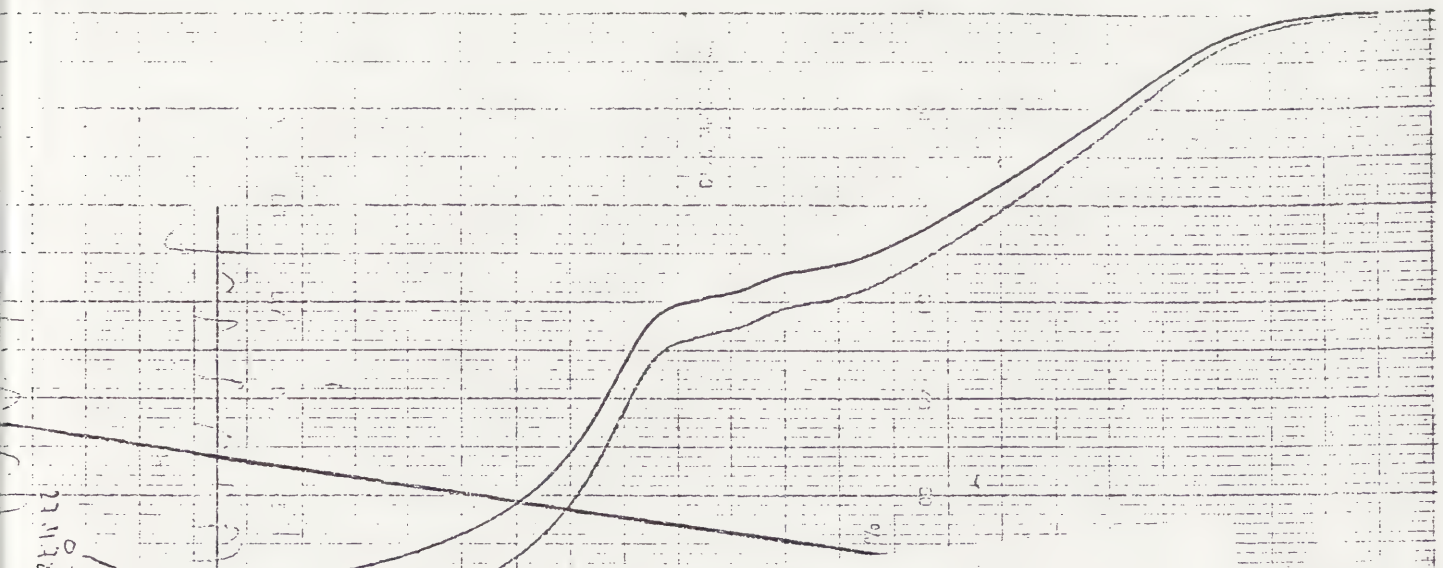

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bzw. 0 - 20%, bzw. 0 - 50%,
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Wellenlängenintervall: 800 - 320 nm

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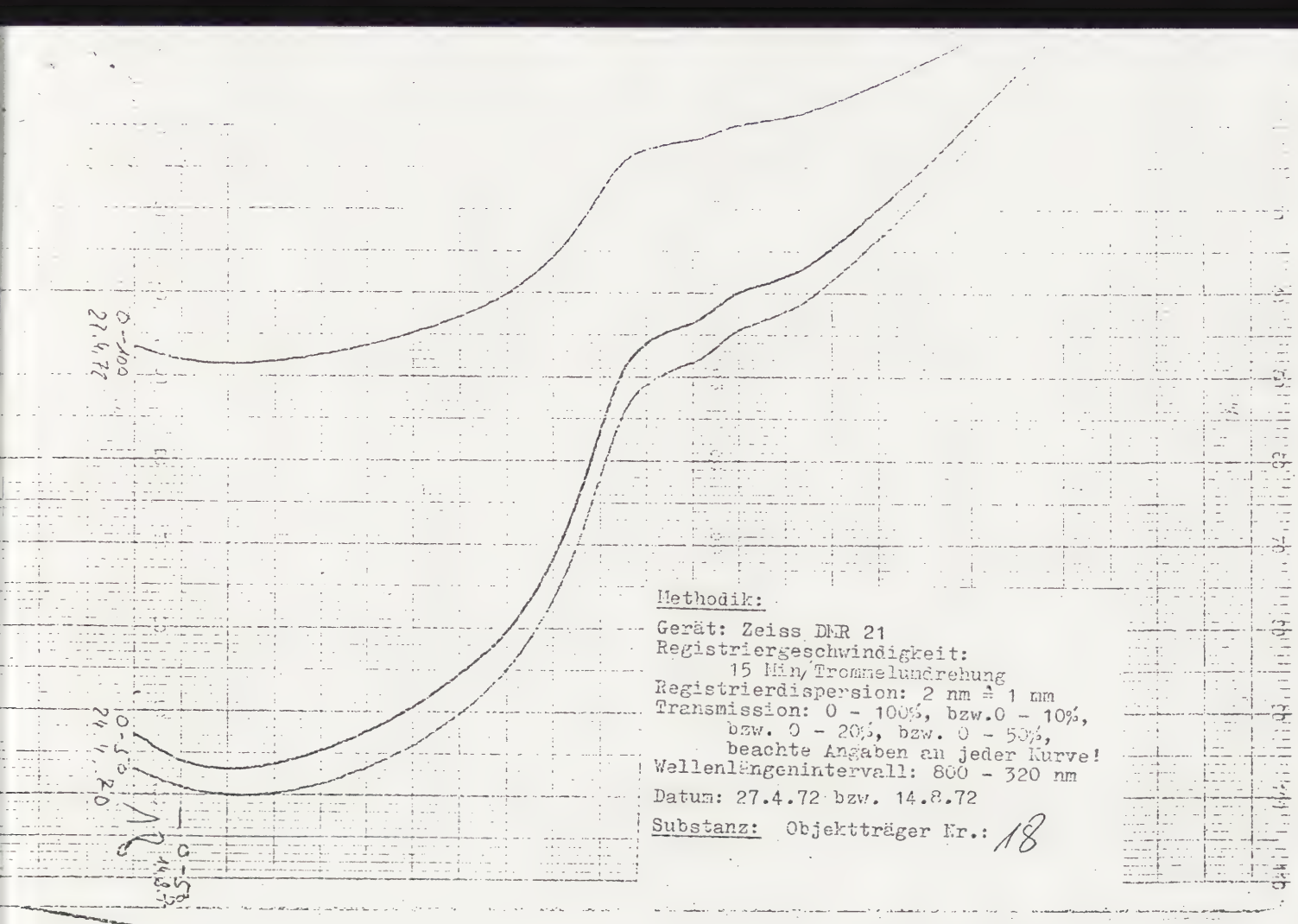
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bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
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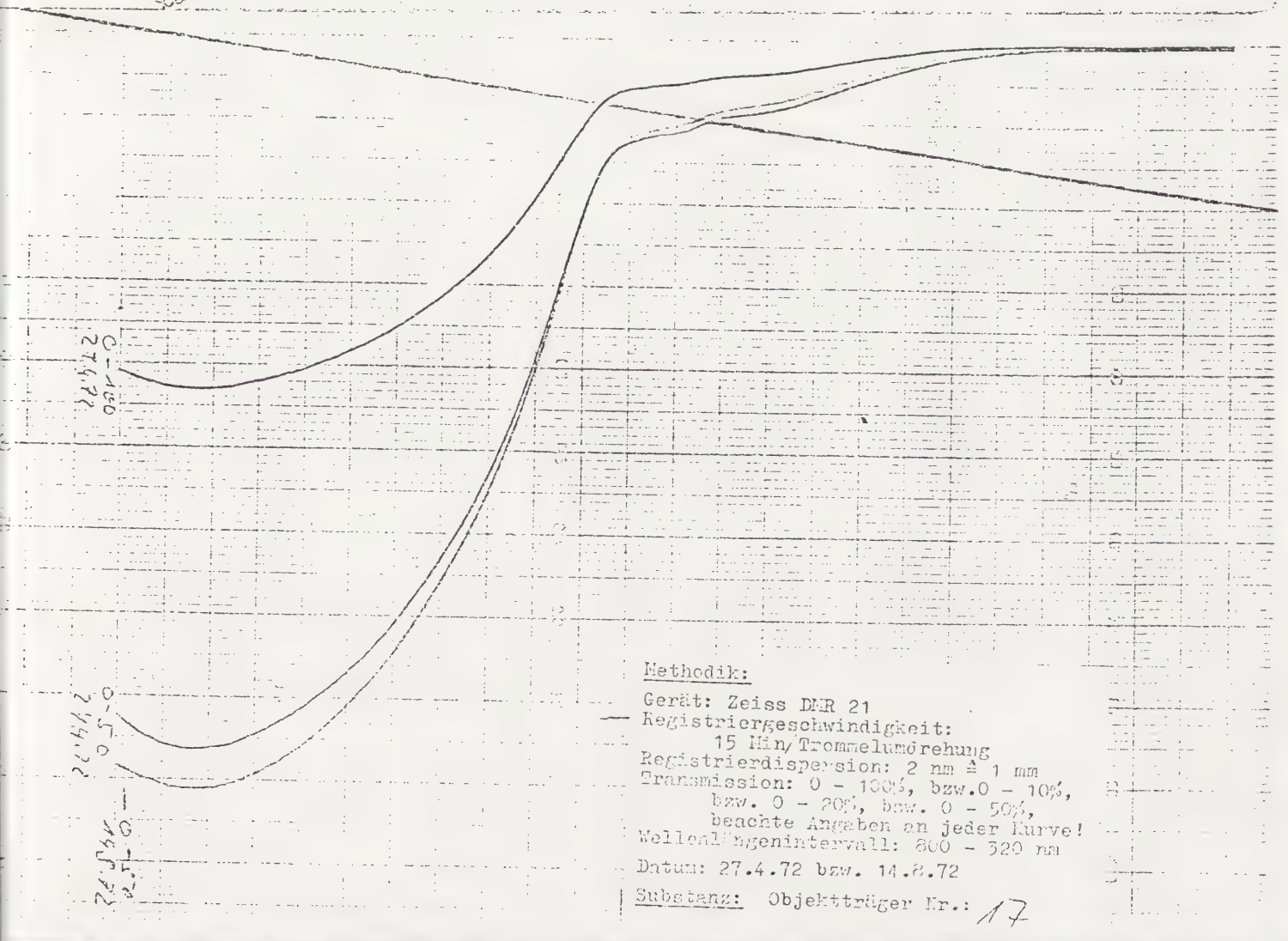
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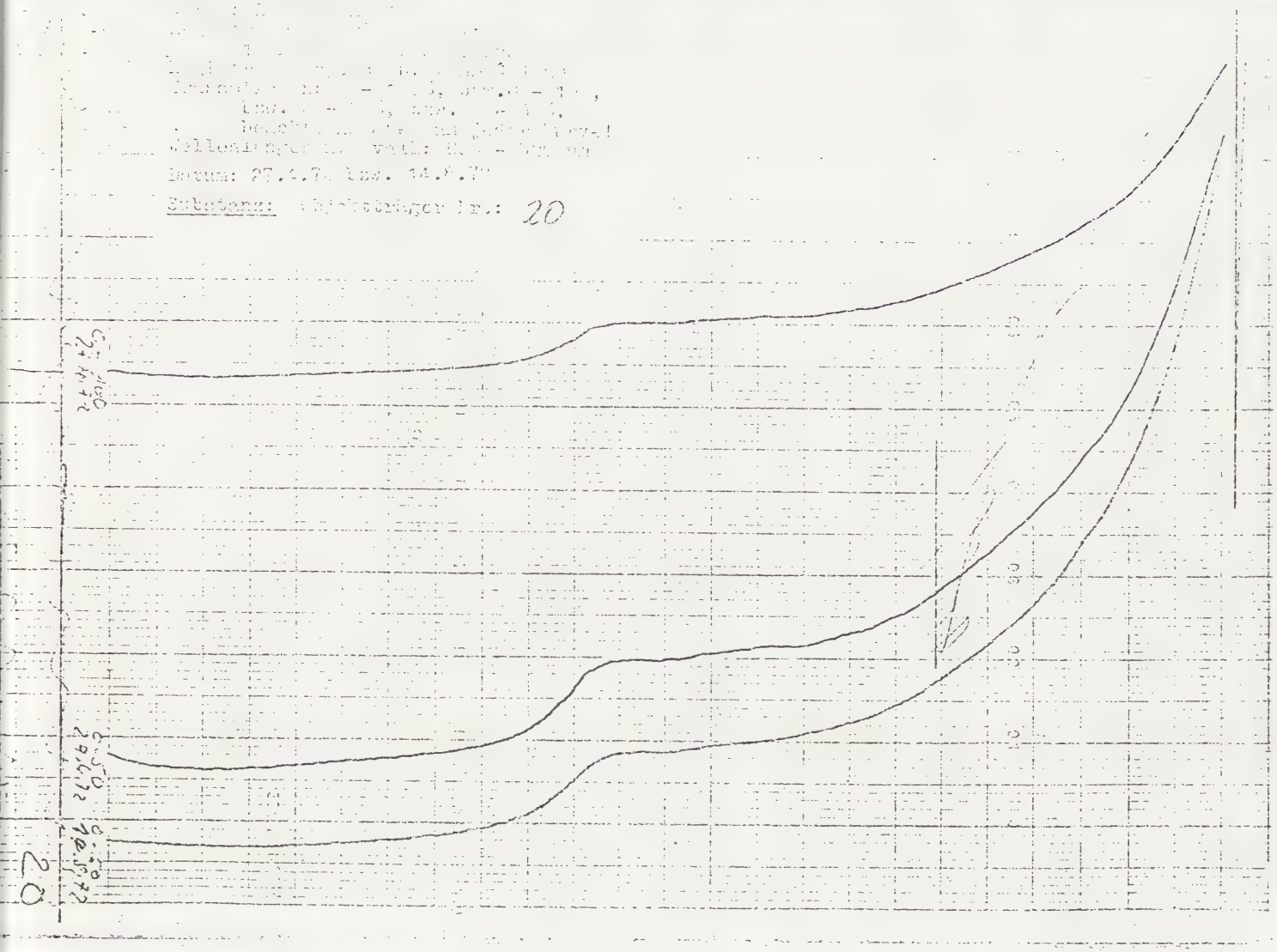
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 27.4.72 bzw. 14.8.72
Substanz: Objektträger Nr.: 17

Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw. 0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 27.4.72 bzw. 14.8.72

Substanz: Objektträger Nr.: 20

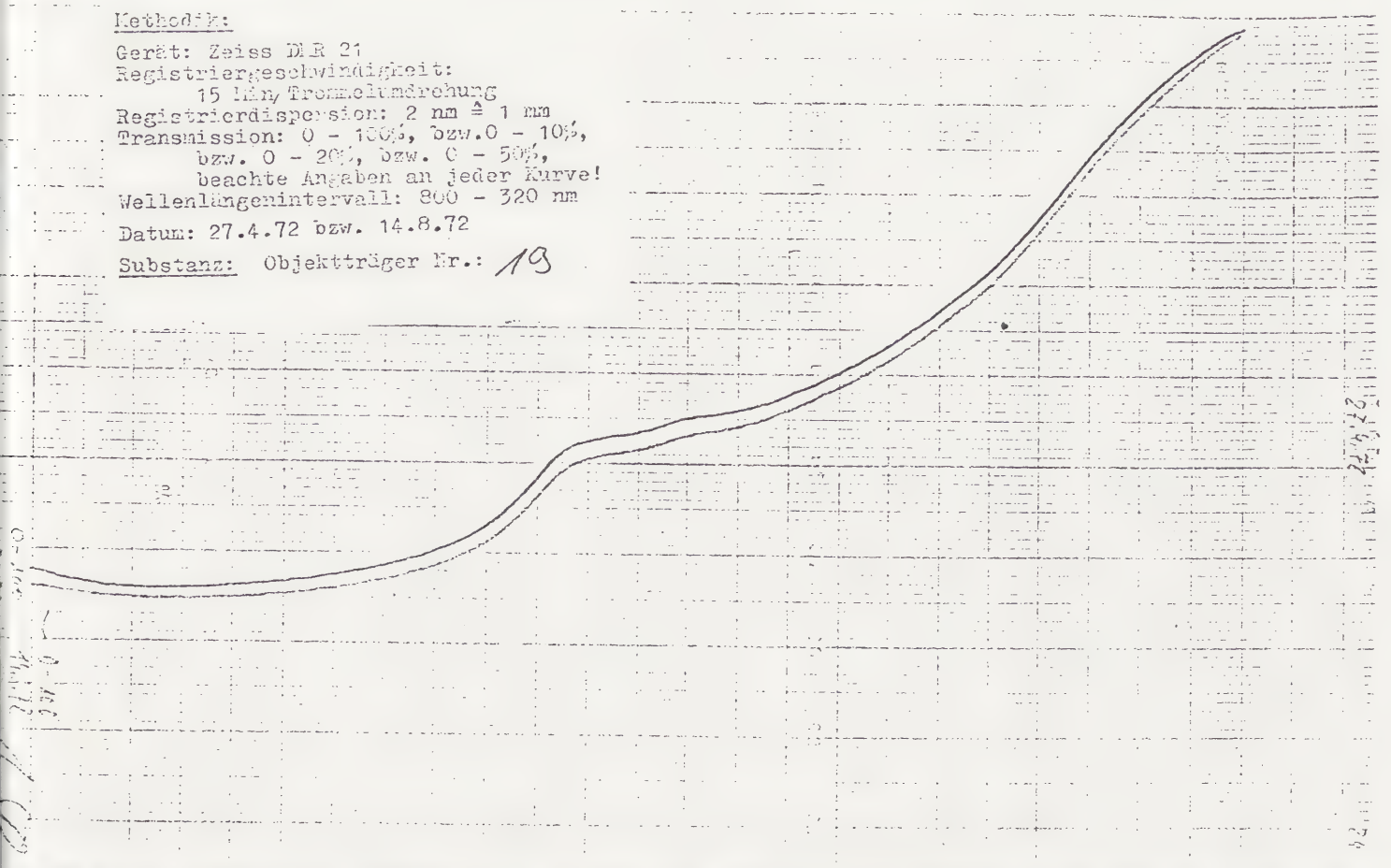


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw. 0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 27.4.72 bzw. 14.8.72

Substanz: Objektträger Nr.: 19

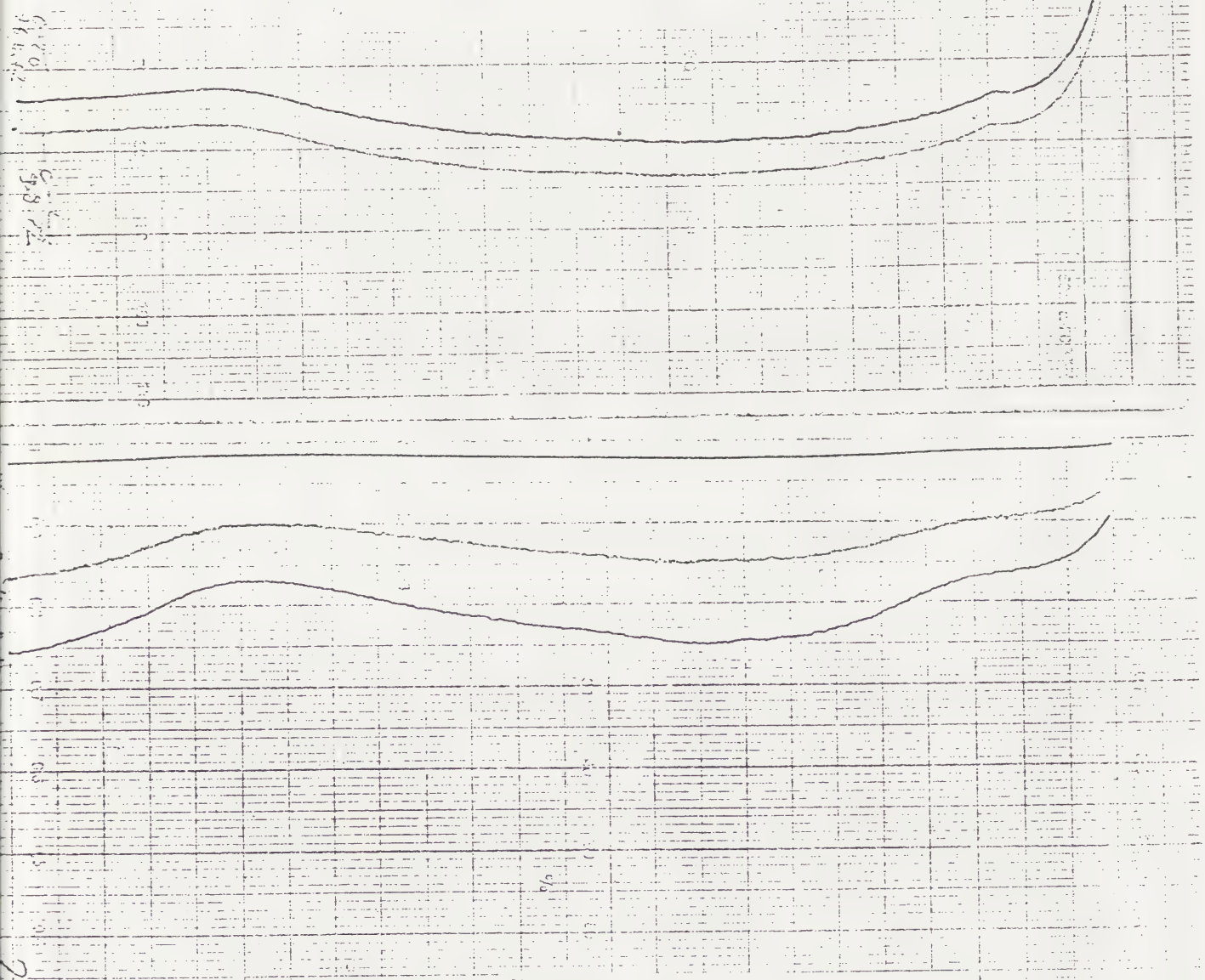


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 26.4.72 bzw. 9.8.72

Substanz: Objektträger Nr.: 22

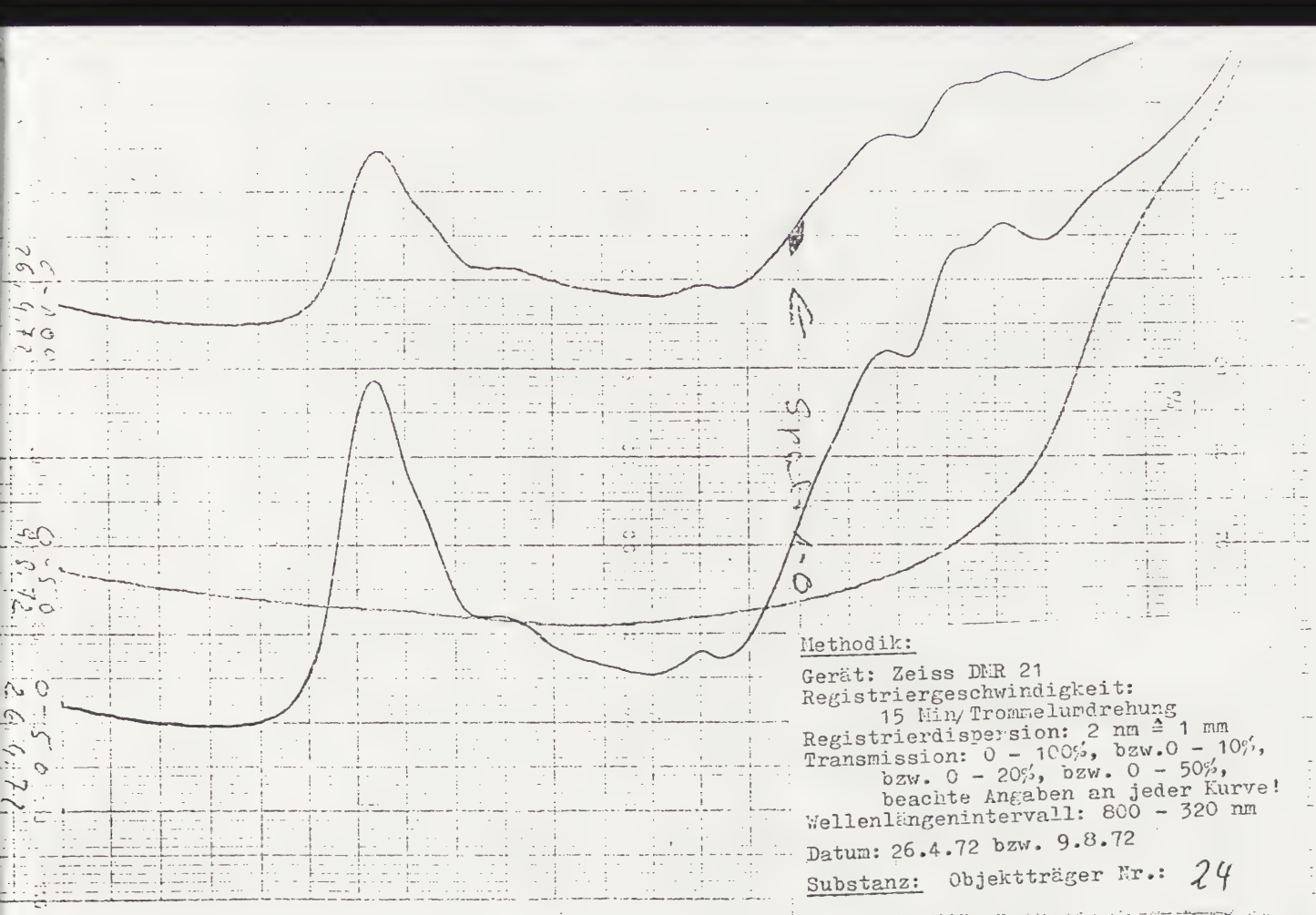


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 27.4.72 bzw. 14.8.72

Substanz: Objektträger Nr.: 21

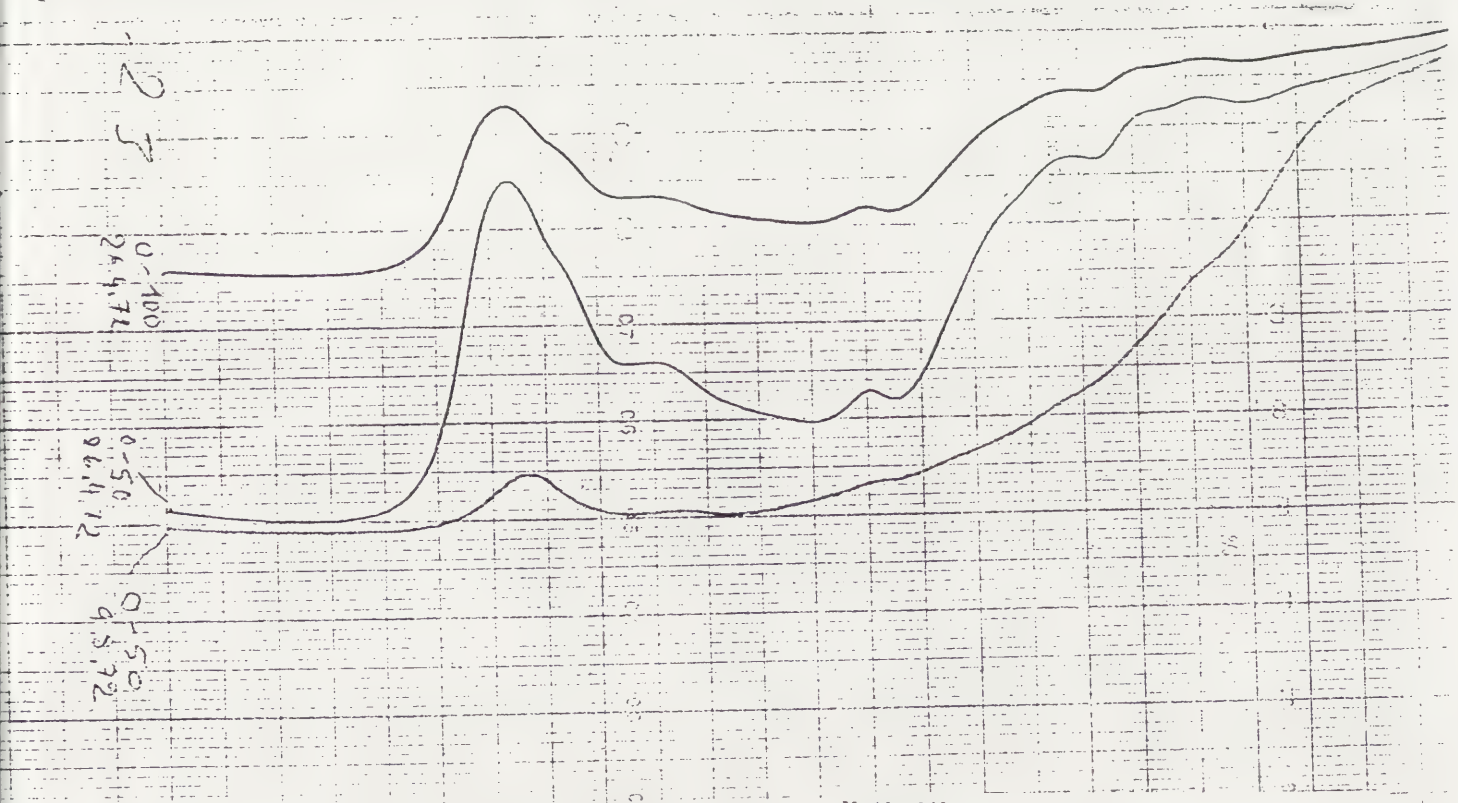


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 26.4.72 bzw. 9.8.72

Substanz: Objektträger Nr.: 24

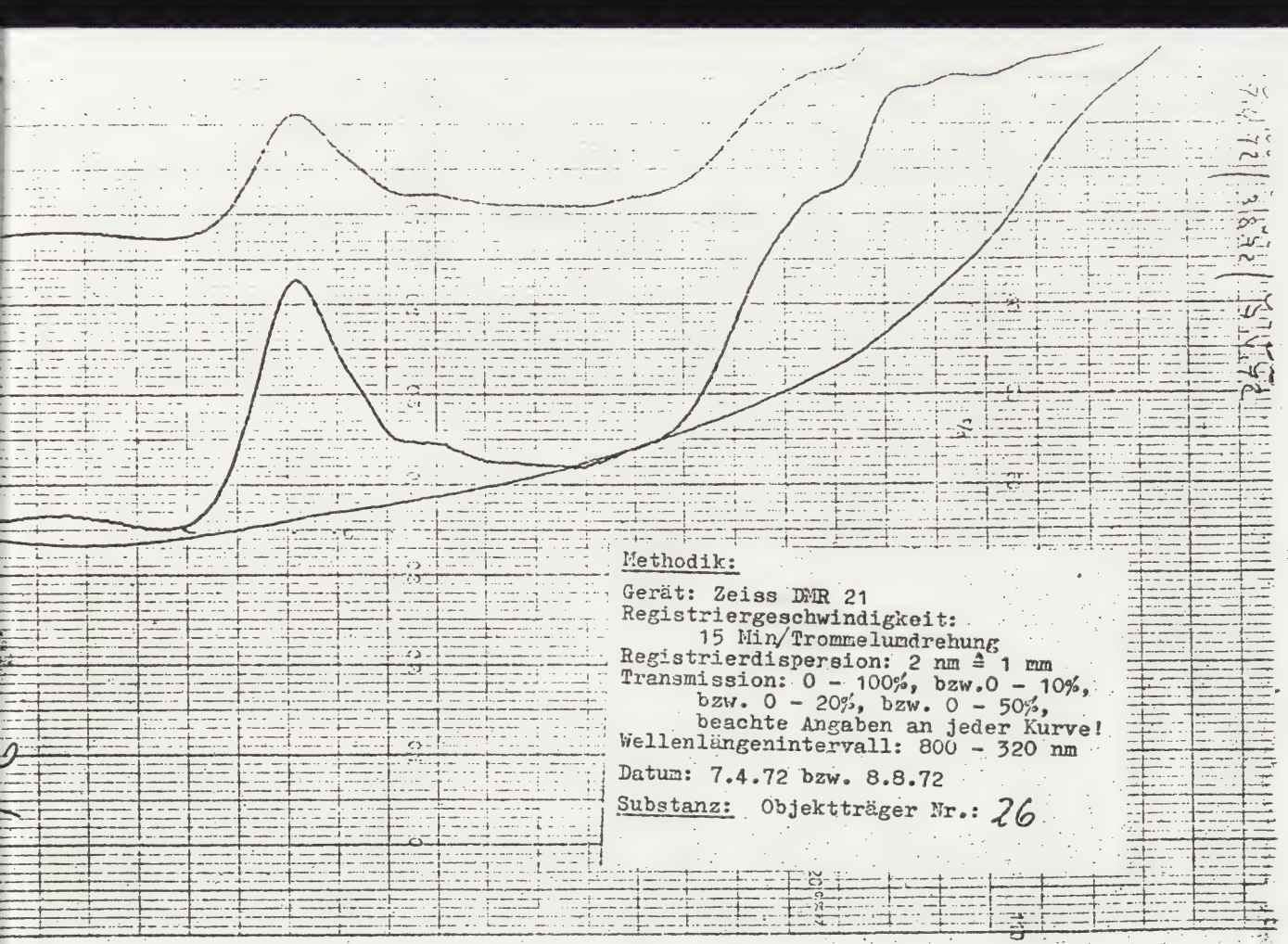


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 26.4.72 bzw. 9.8.72

Substanz: Objektträger Nr.: 23

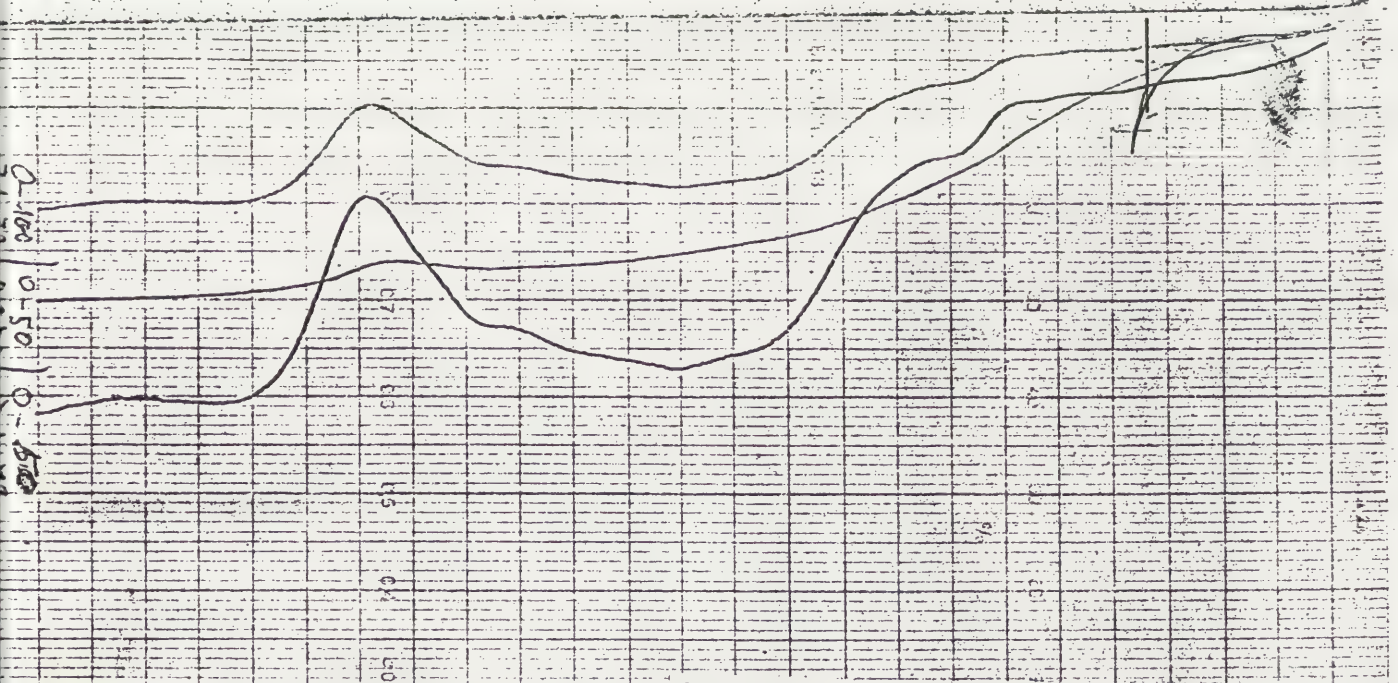


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 7.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 26

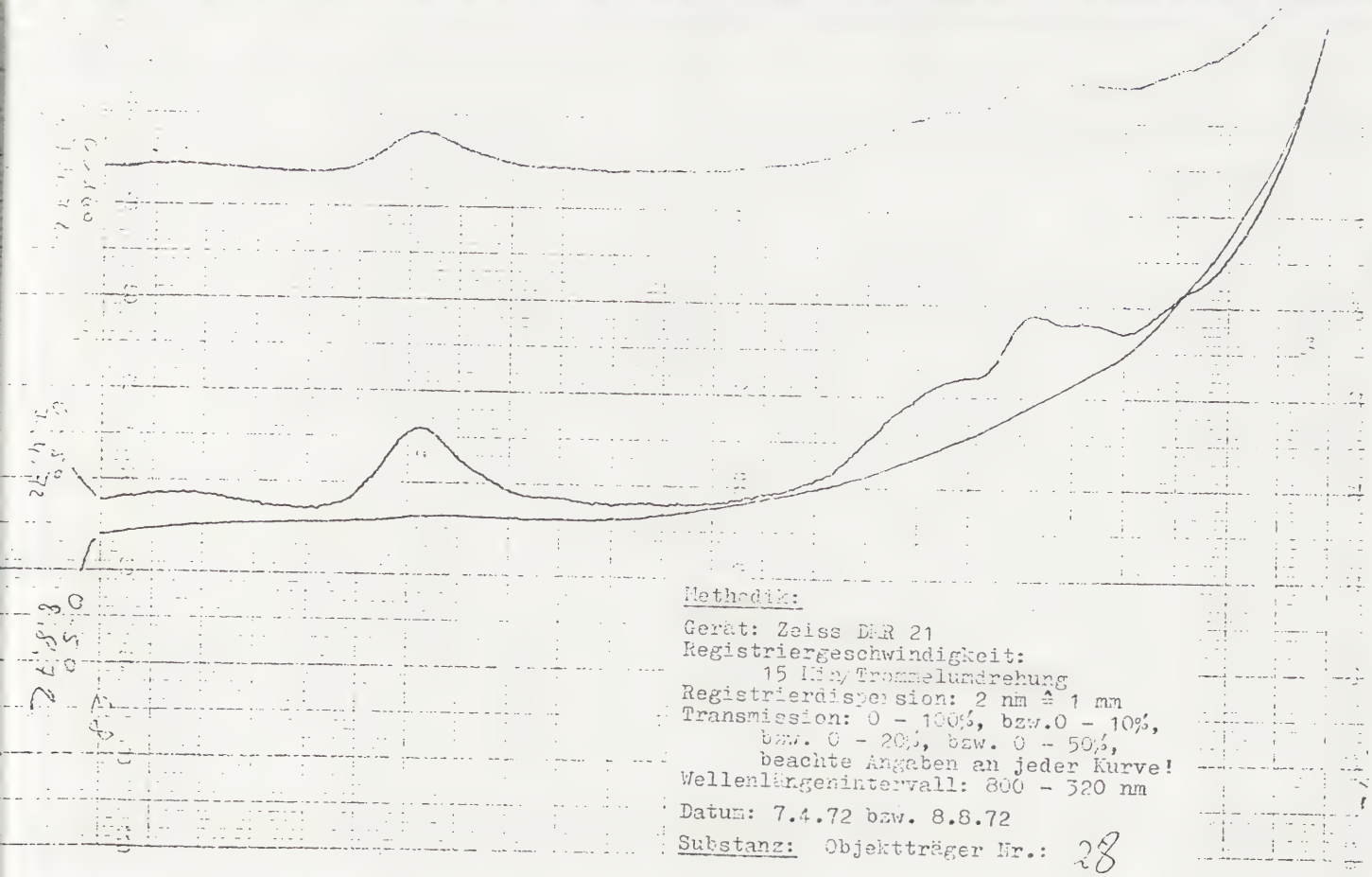


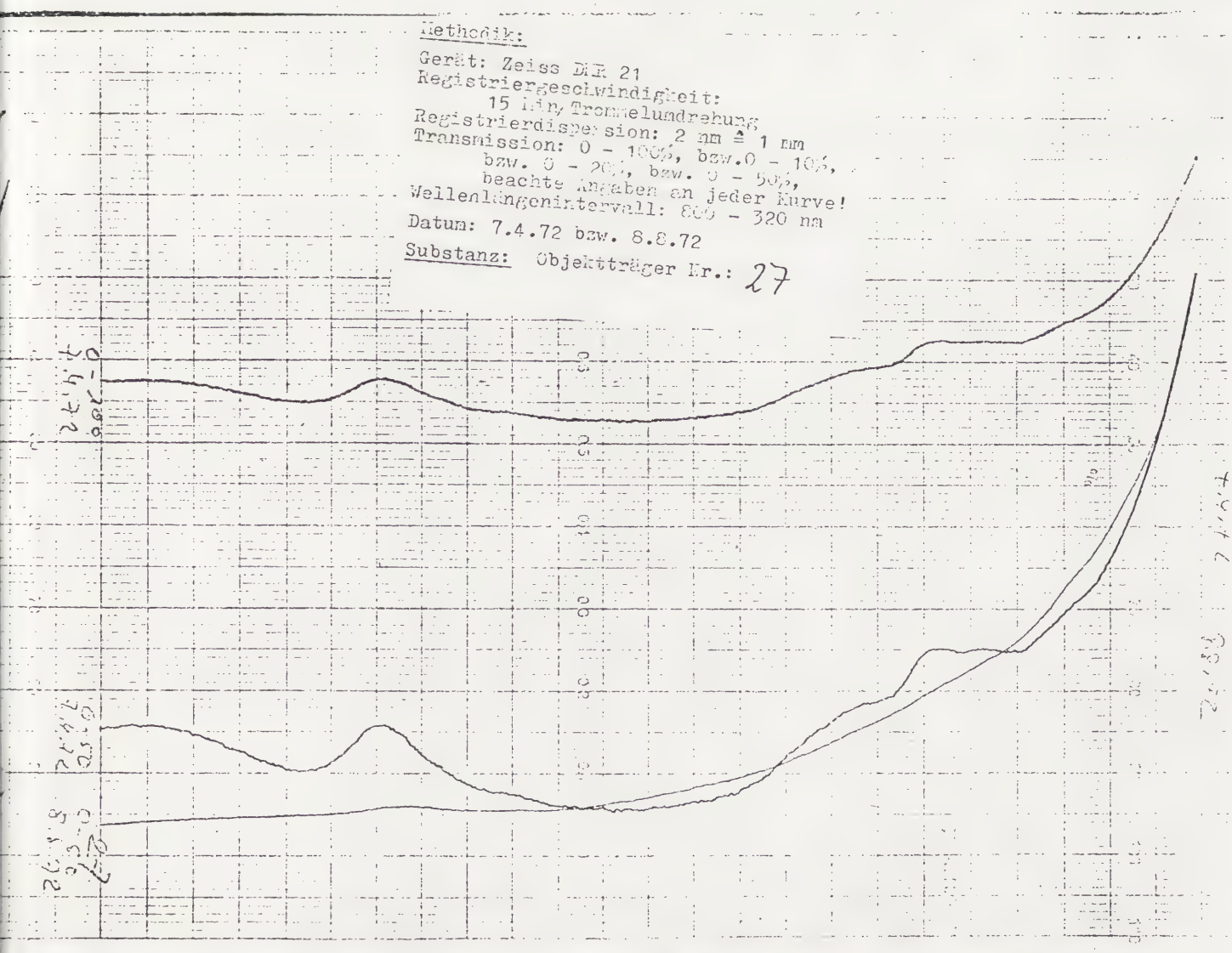
Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 7.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 25


Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 mm/Trommelumdrehung
Registrierdispersion: 2 mm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 7.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.: 28


Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 mm/Trommelumdrehung
Registrierdispersion: 2 mm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 7.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.: 27

Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 nm
Transmission: 0 - 100%, bzw. 0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 6.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.: 30

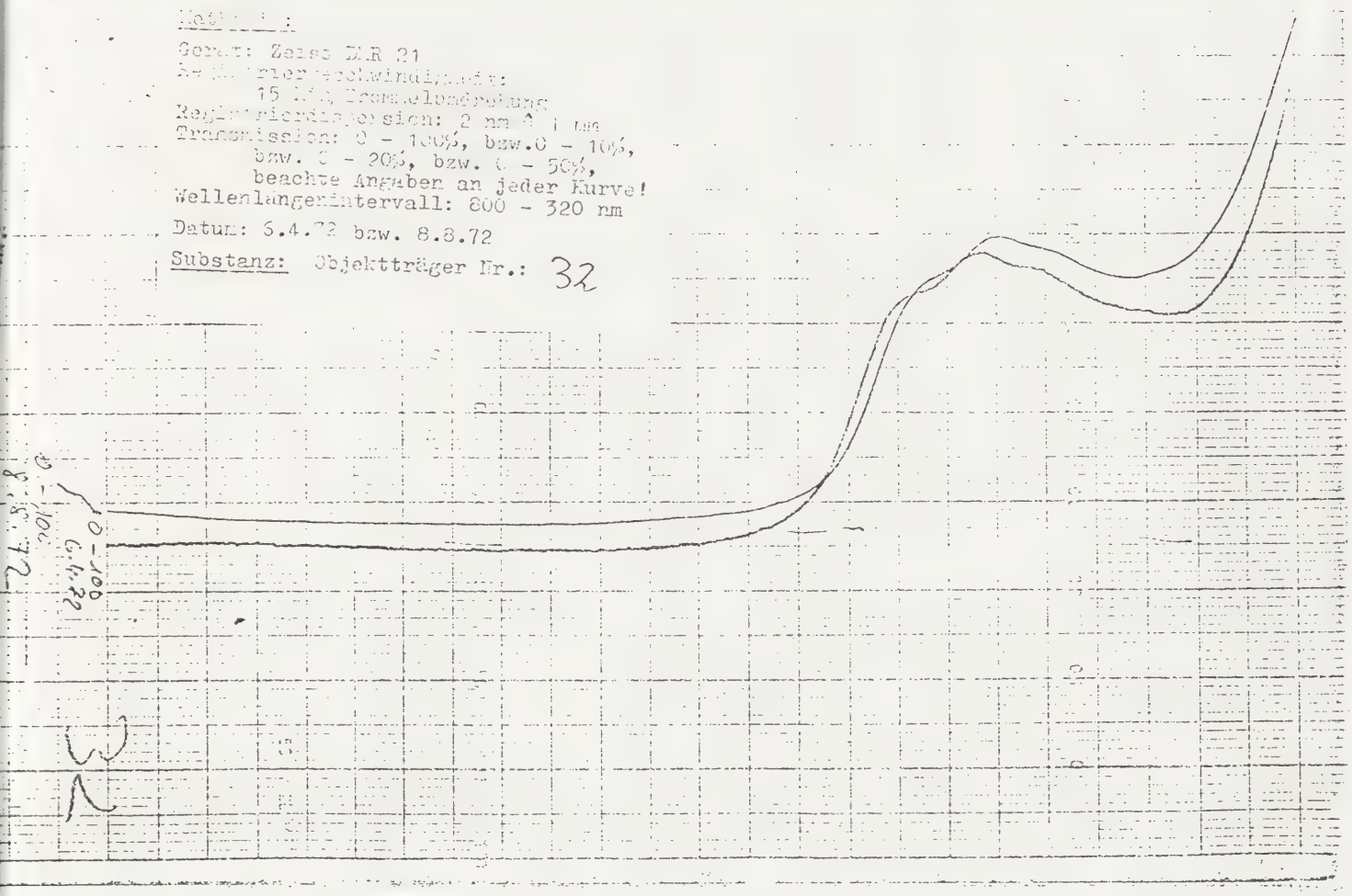
Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 nm
Transmission: 0 - 100%, bzw. 0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 6.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.: 29

Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 32

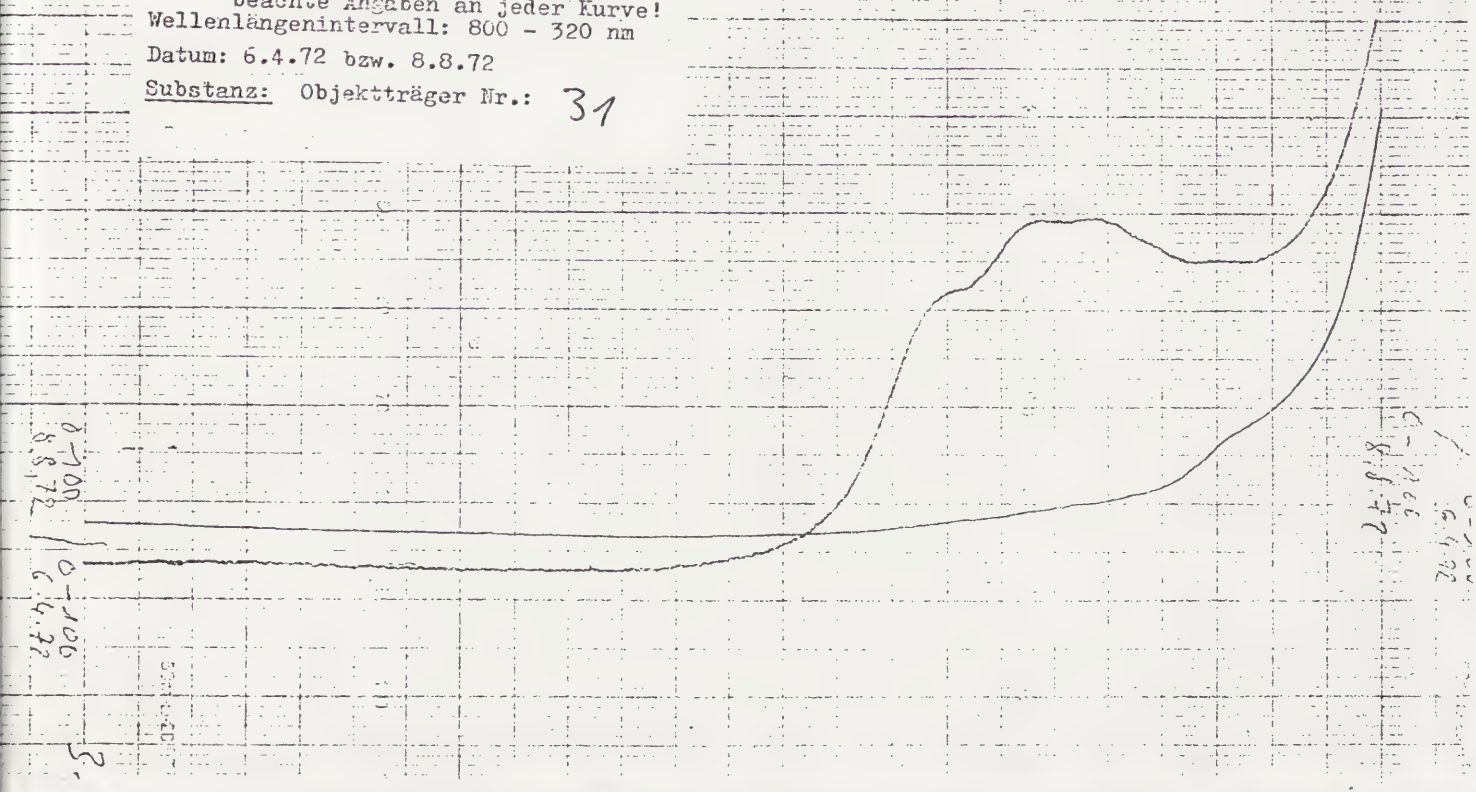


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 31



Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

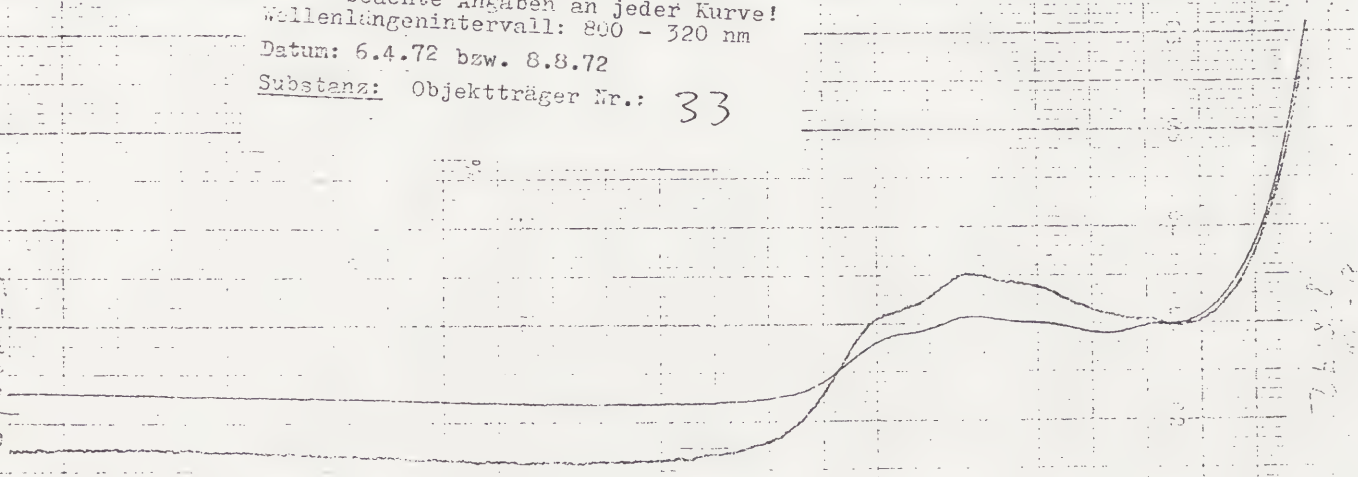
Substanz: Objektträger Nr.: 34

Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 33

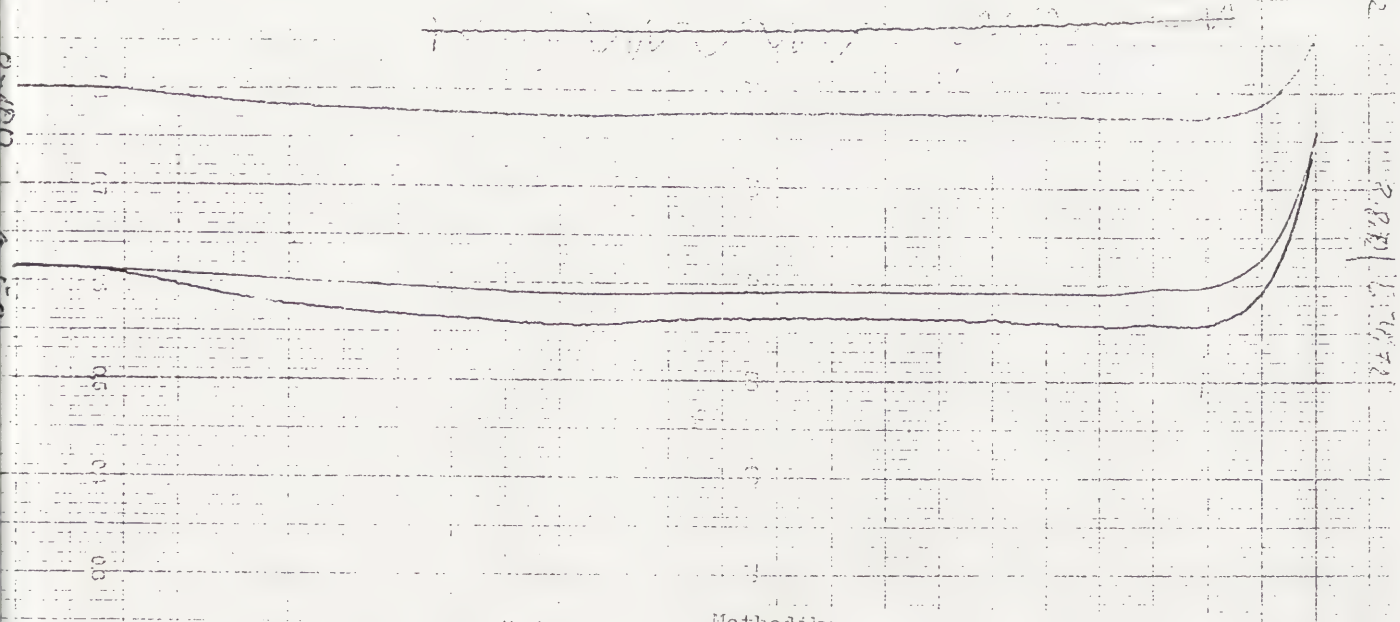


Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 36



Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 35

Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.:

38

Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.: 37

Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 5.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.:

40

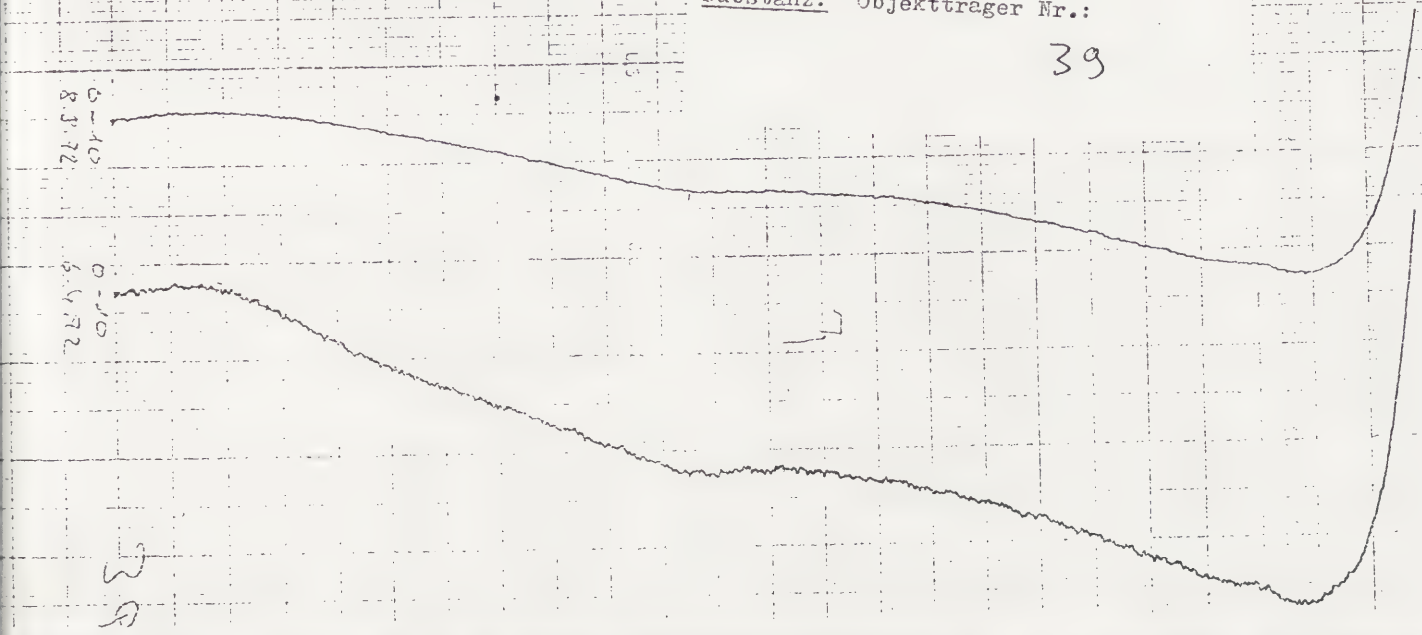
Methodik:

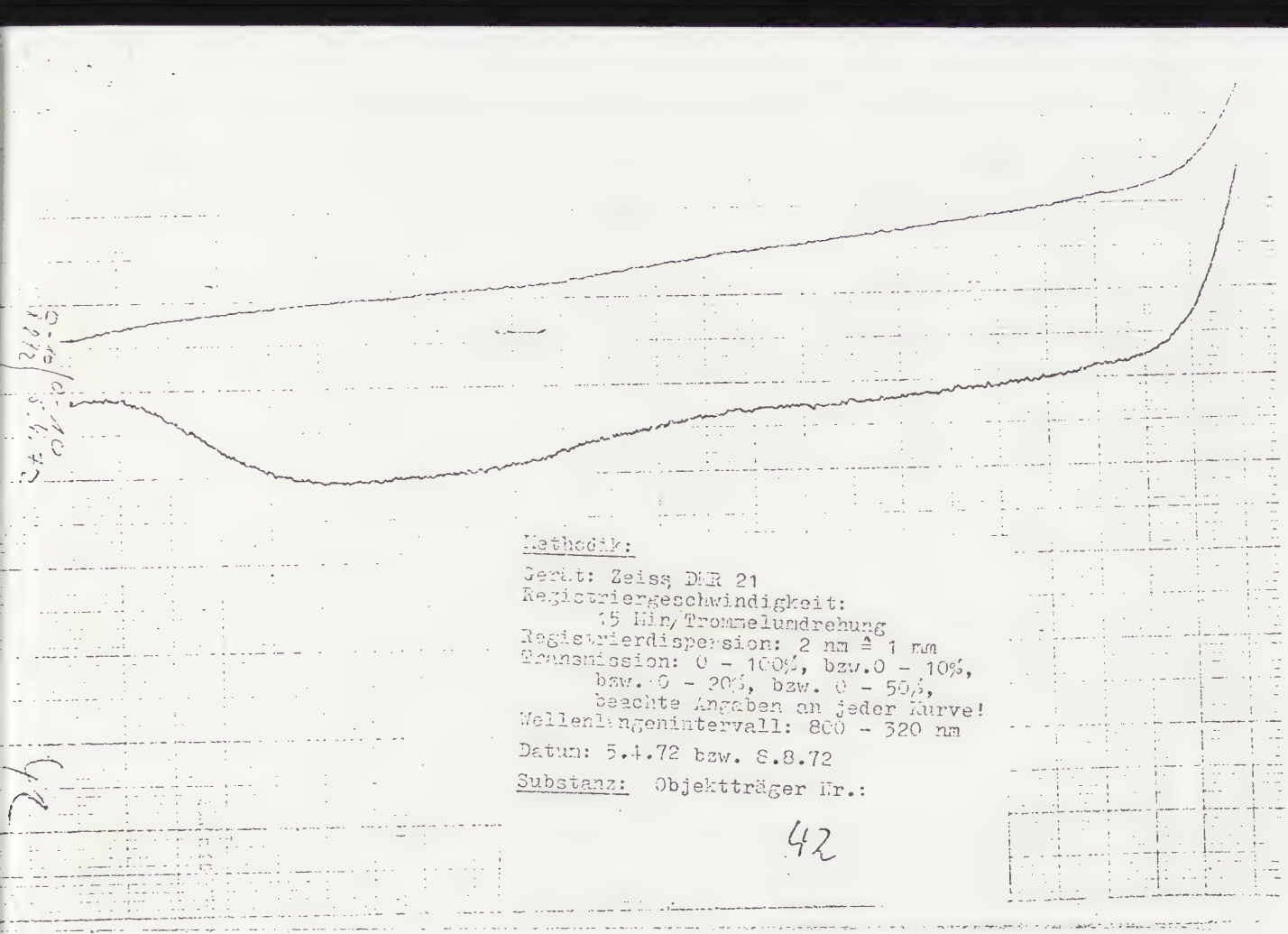
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 6.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.:

39





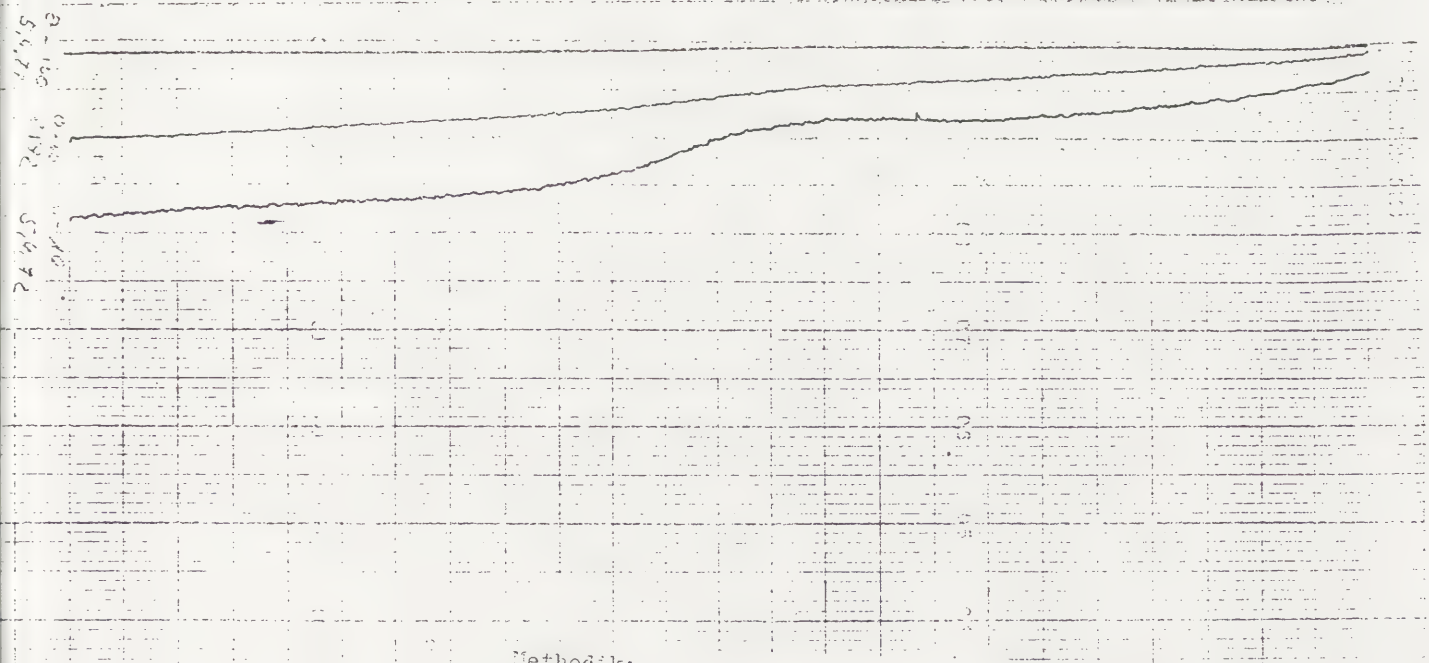
Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 5.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.:

42



Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm

Datum: 5.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.:

41

Methodik:

Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 mm Trommelumdrehung
Registrierdispersion: 2 mm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 600 - 320 nm

Datum: 5.4.72 bzw. 8.8.72

Substanz: Objektträger Nr.:

43

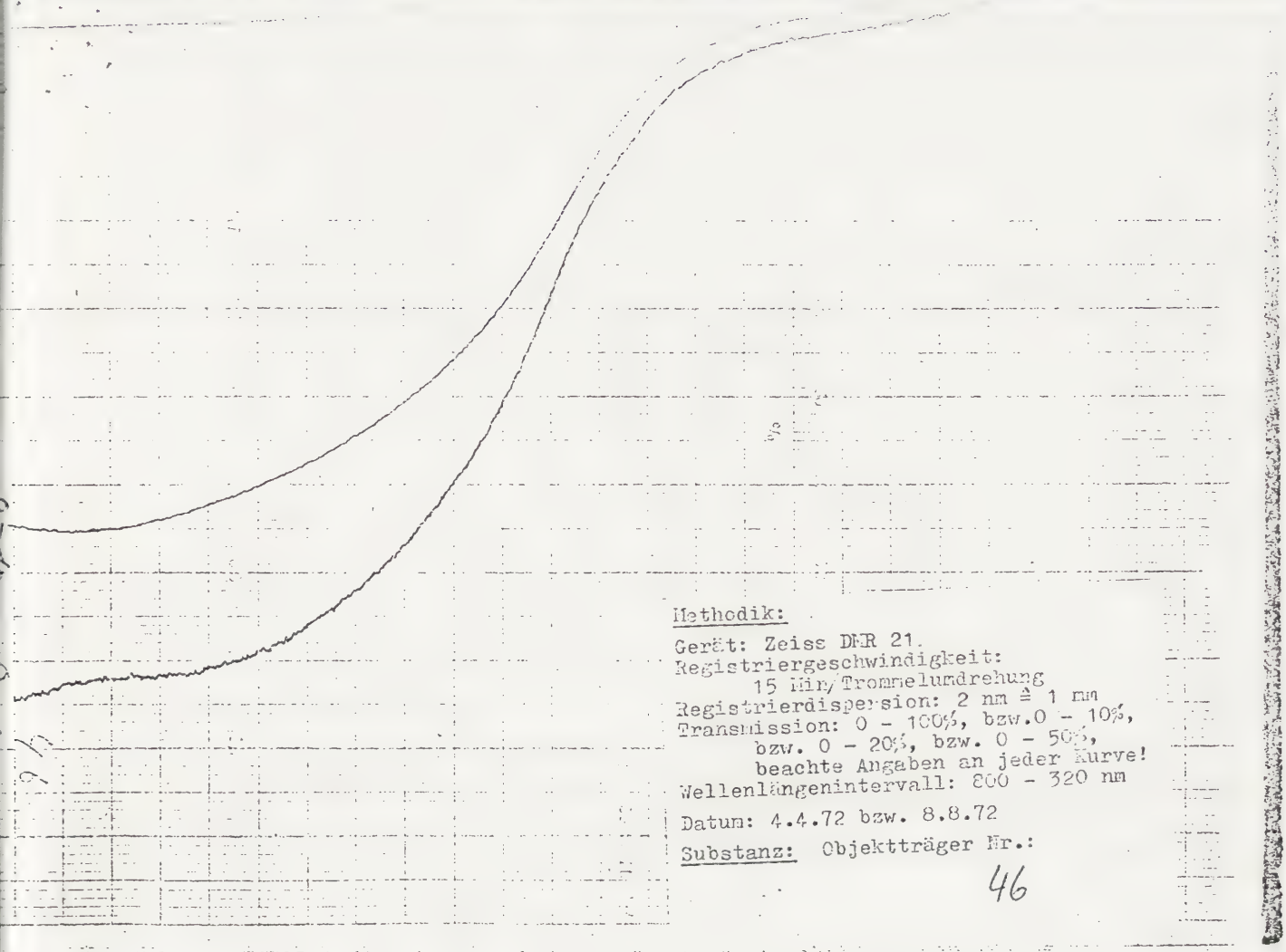
Methodik:

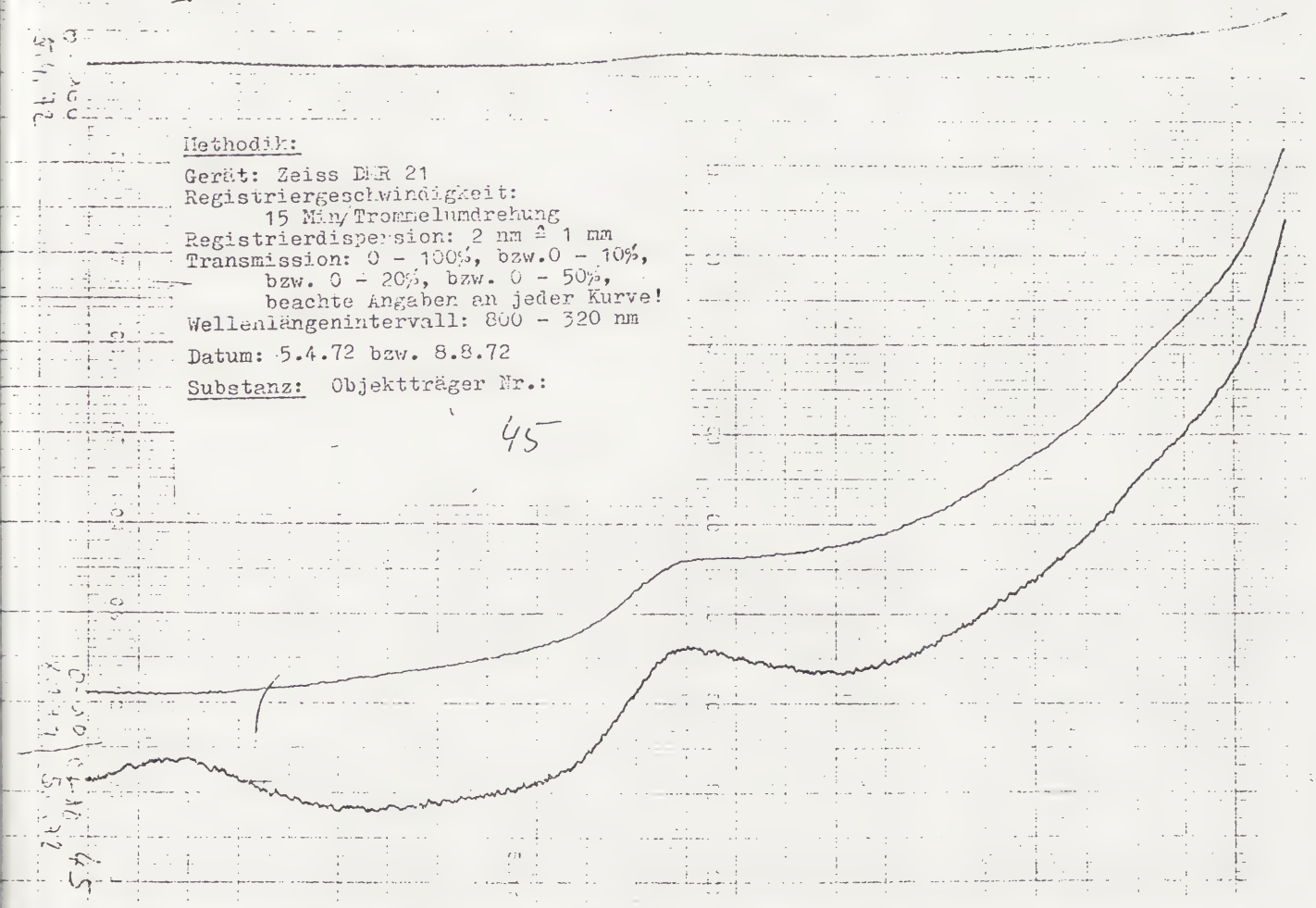
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 mm Trommelumdrehung
Registrierdispersion: 2 mm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 600 - 320 nm

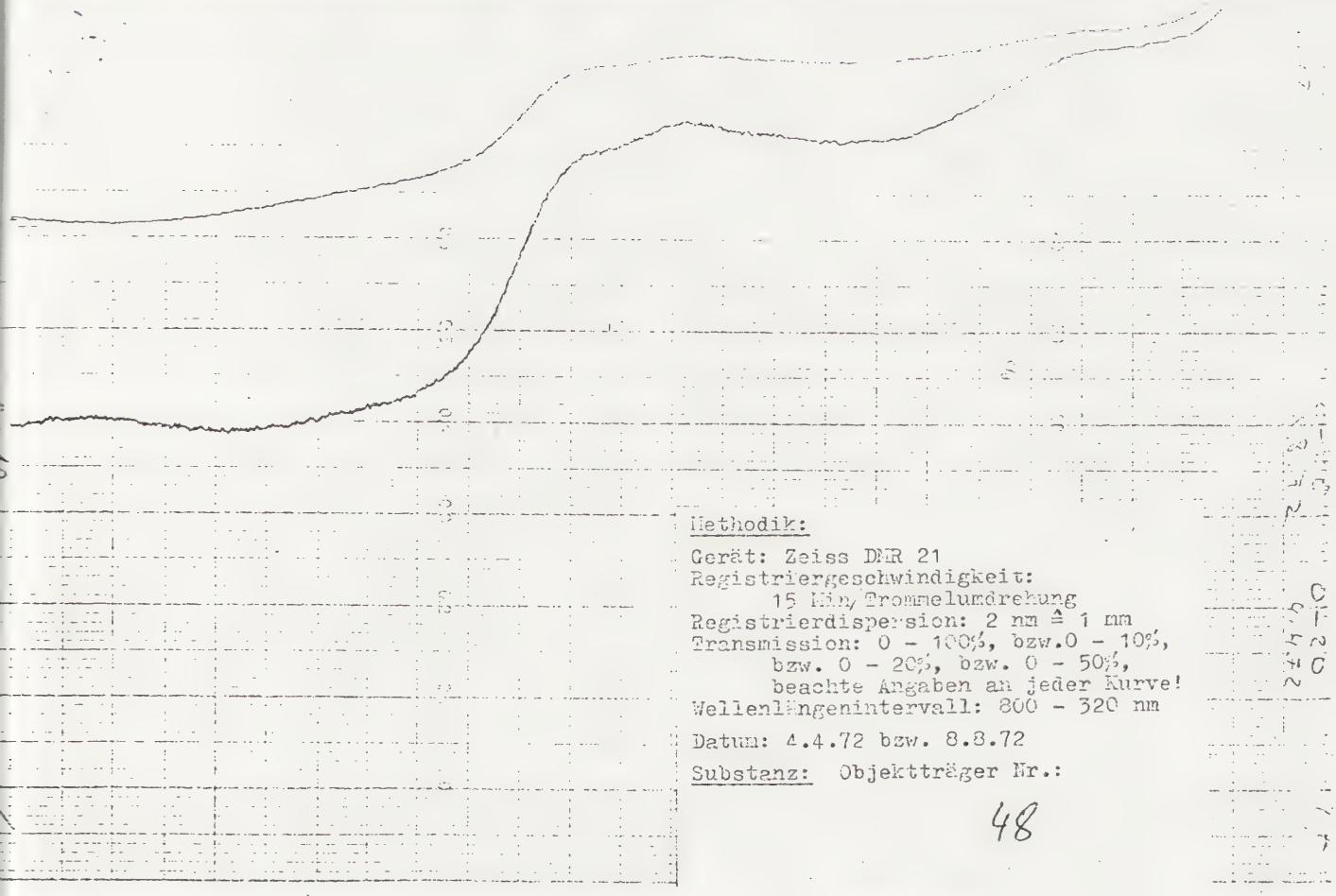
Datum: 5.4.72 bzw. 8.8.72

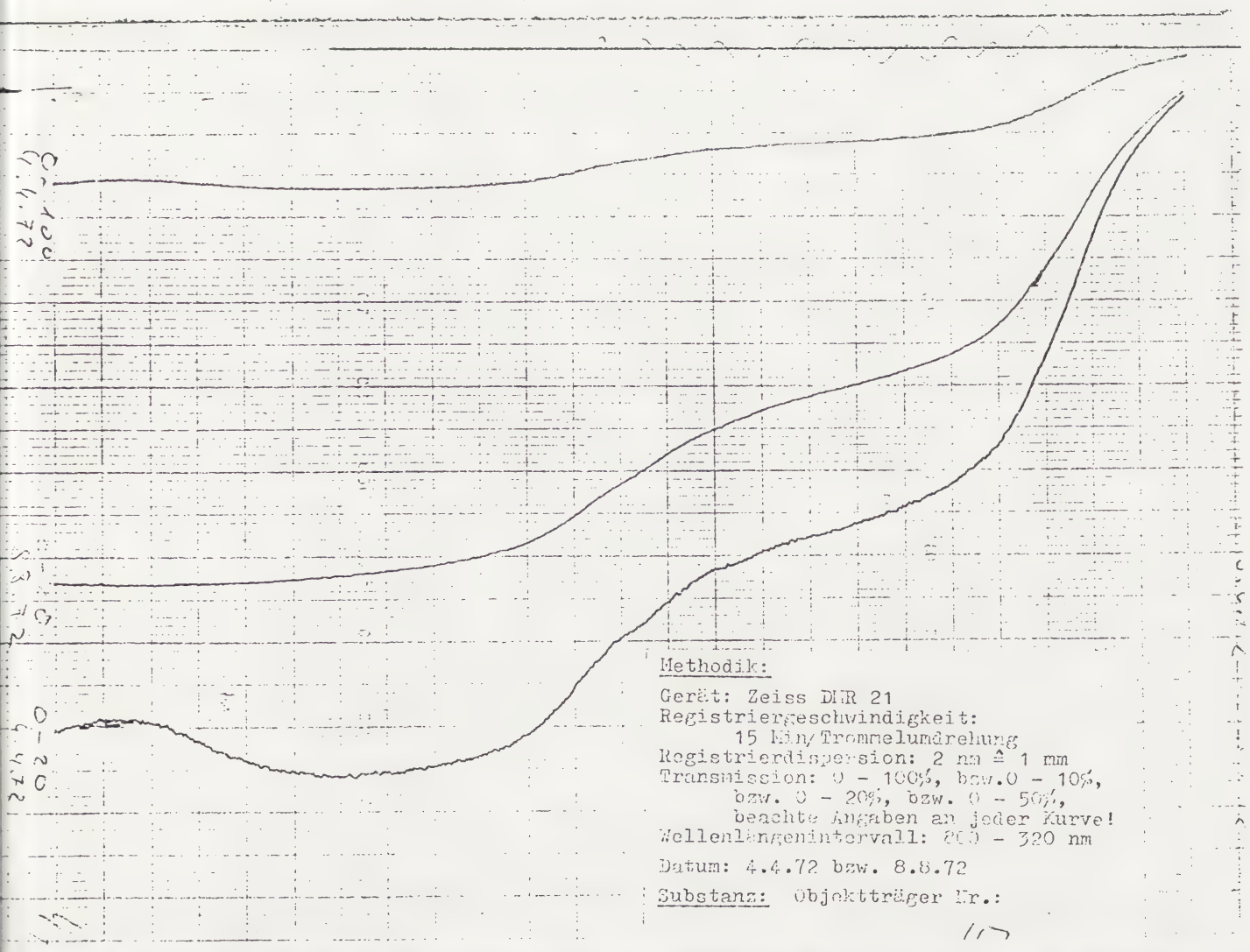
Substanz: Objektträger Nr.:

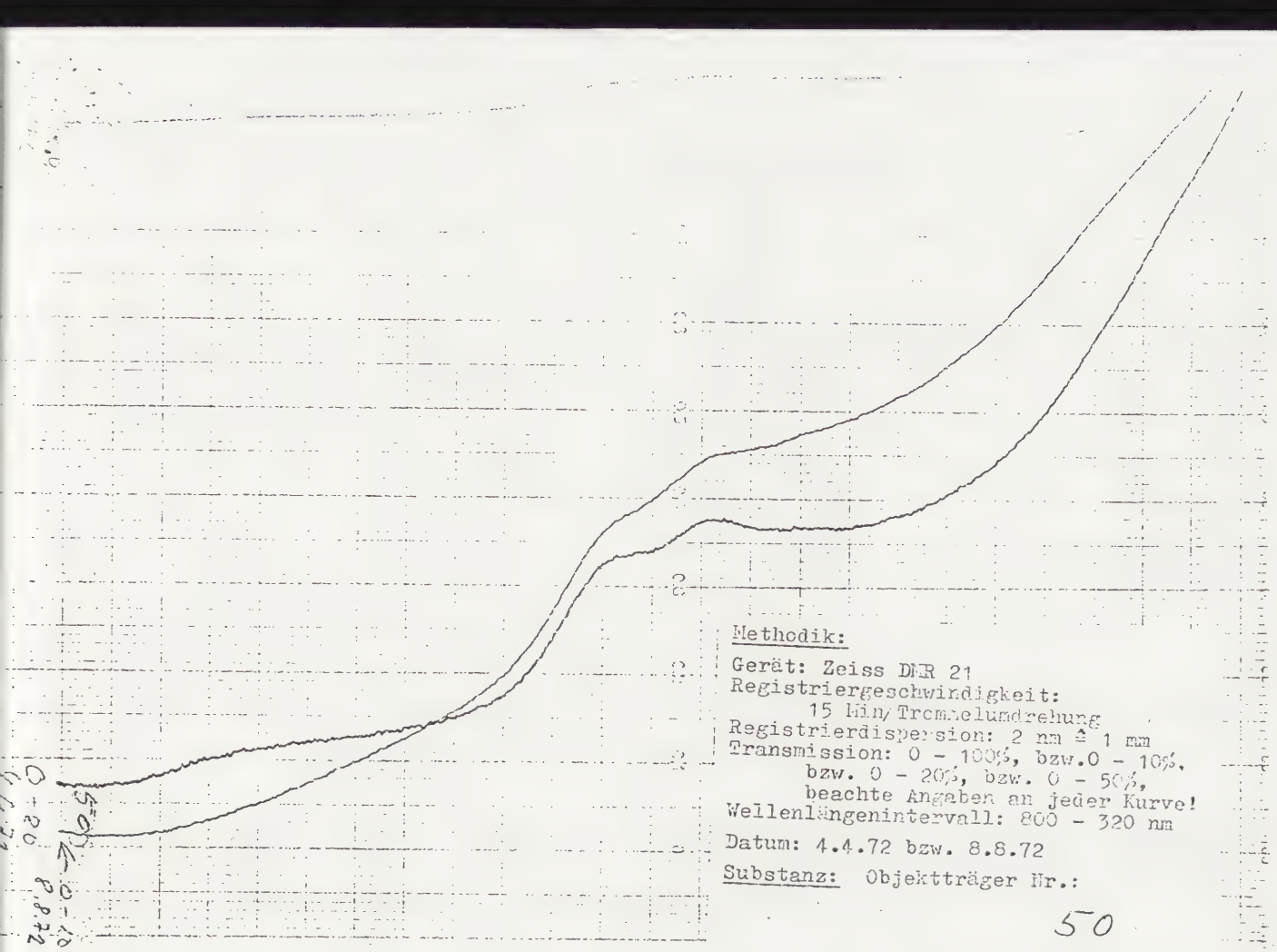
44

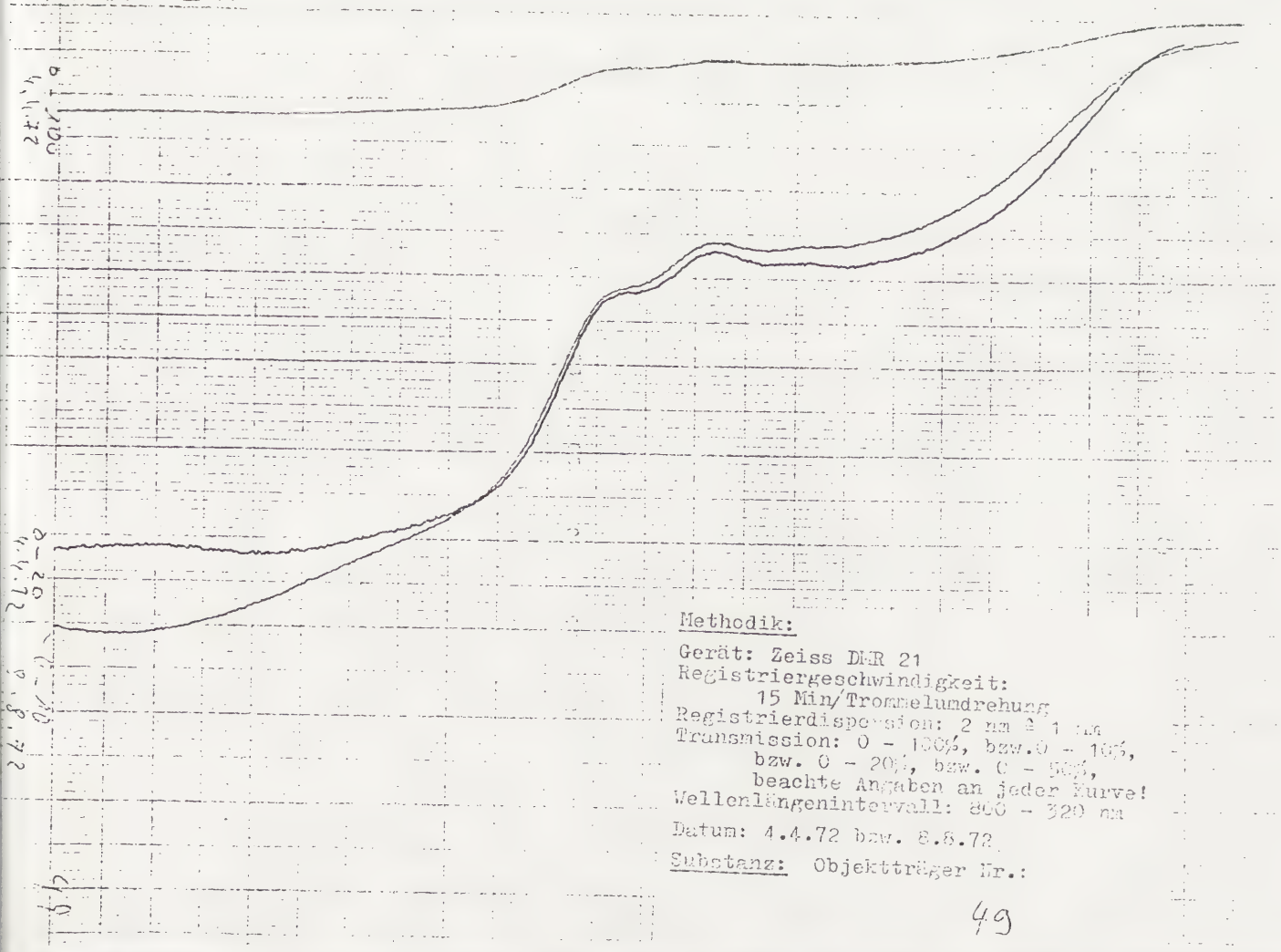

Methodik:
Gerät: Zeiss DMR 21.
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 4.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.:
46

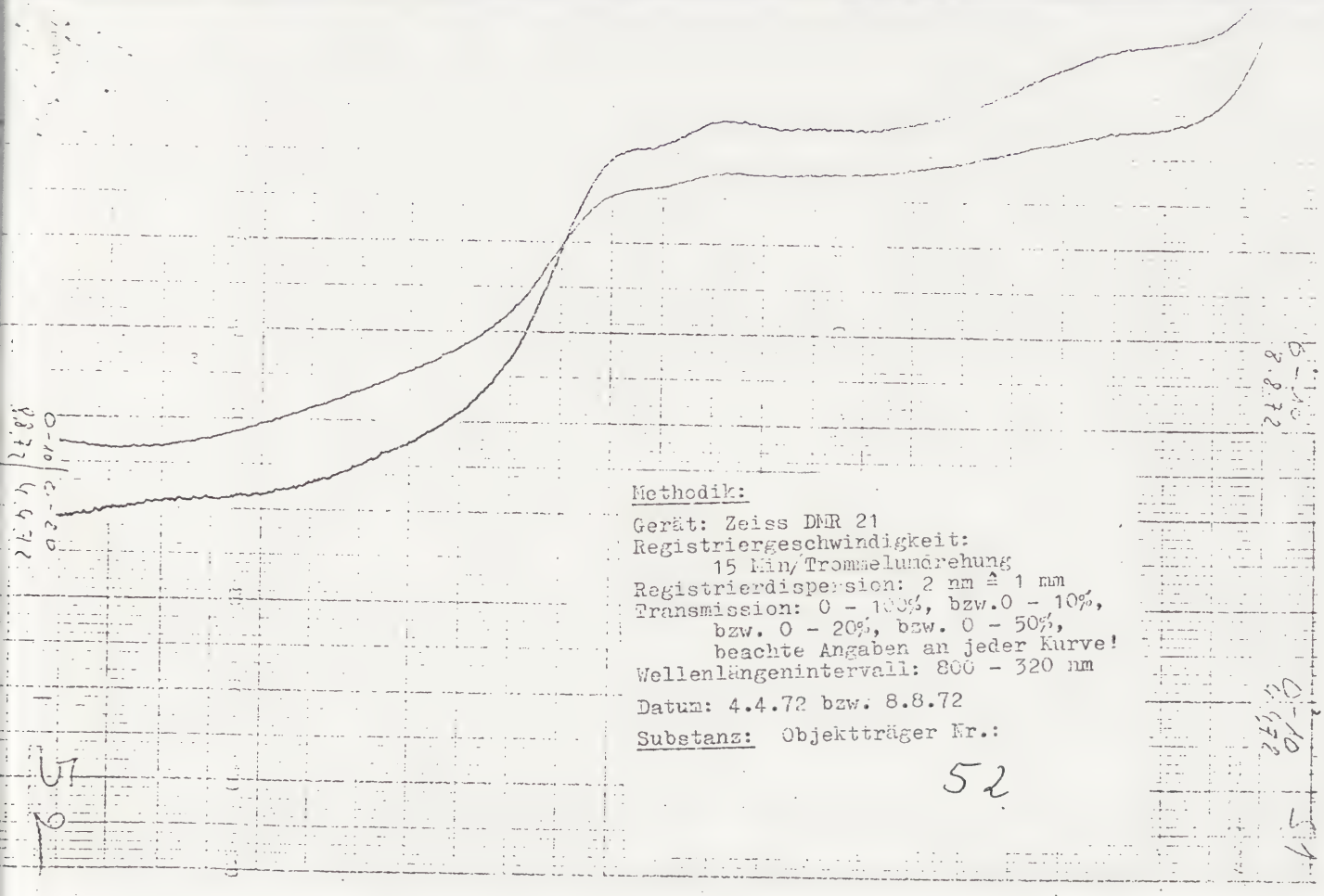

Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 5.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.:
45

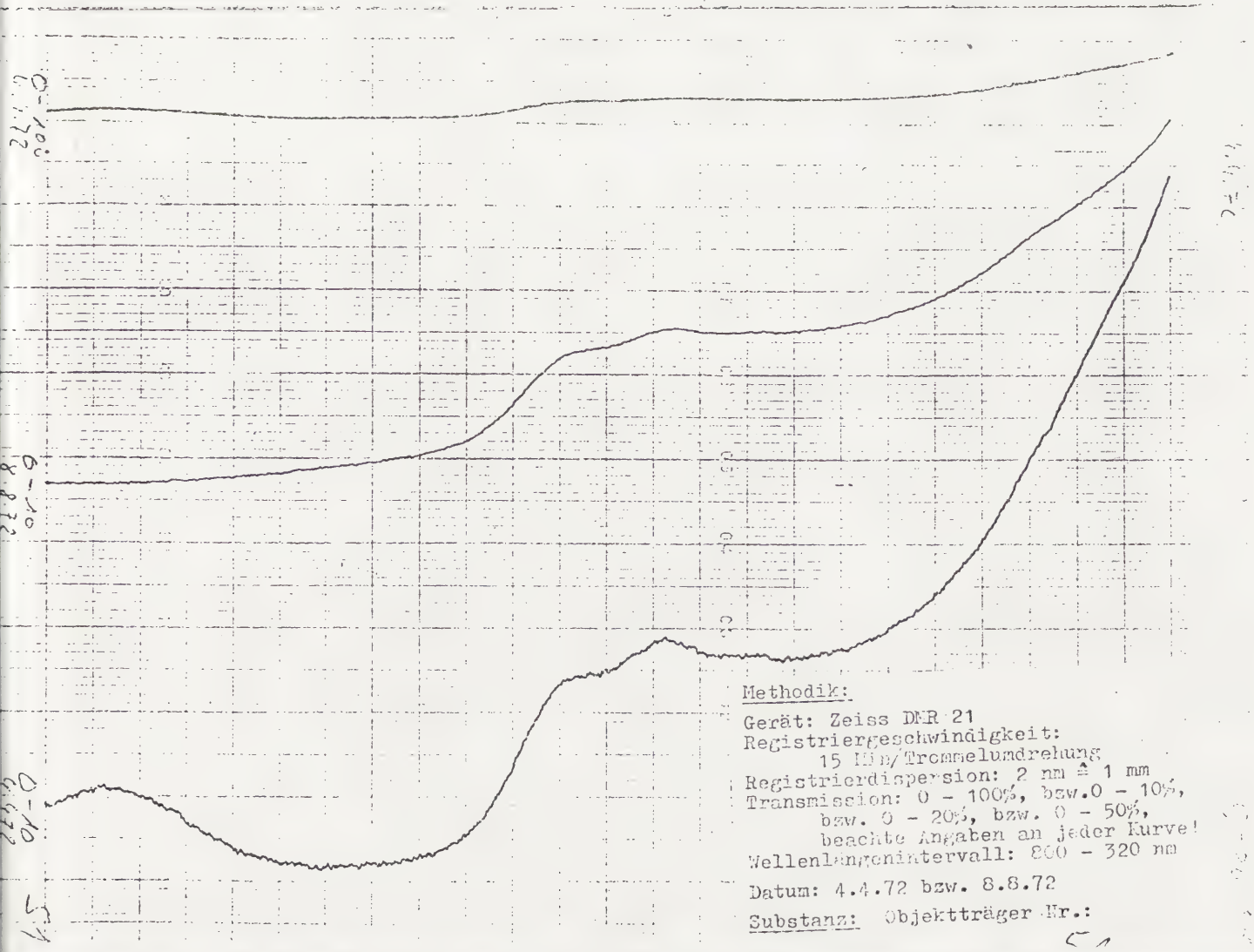

Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 4.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.:
48


Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 4.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.:


Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 4.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.:
50


Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 4.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.:
49


Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
Wellenlängenintervall: 800 - 320 nm
Datum: 4.4.72 bzw. 8.8.72
Substanz: Objektträger Nr.:
52


Methodik:
Gerät: Zeiss DMR 21
Registriergeschwindigkeit:
15 Min/Trommelumdrehung
Registrierdispersion: 2 nm ≙ 1 mm
Transmission: 0 - 100%, bzw.0 - 10%,
bzw. 0 - 20%, bzw. 0 - 50%,
beachte Angaben an jeder Kurve!
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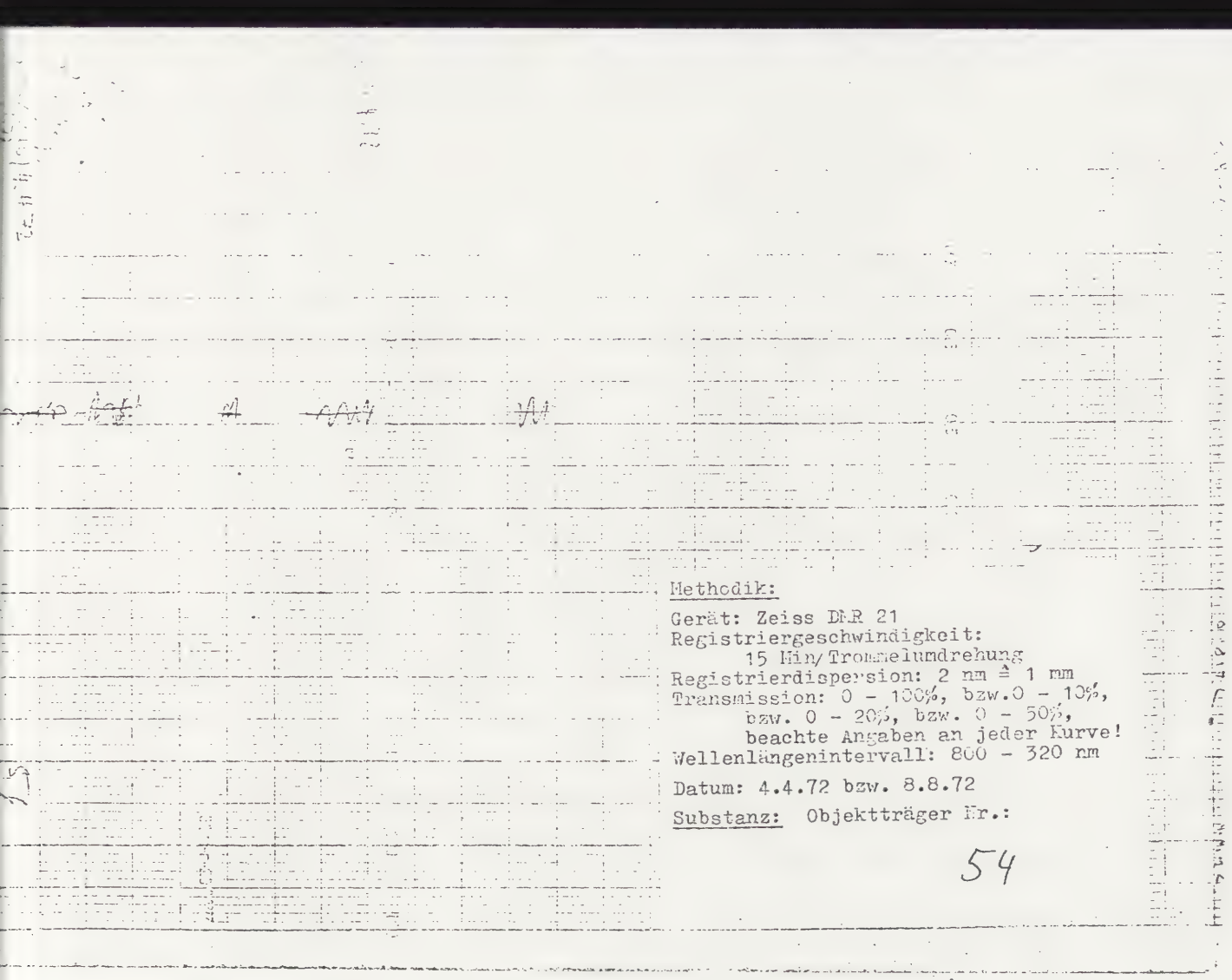

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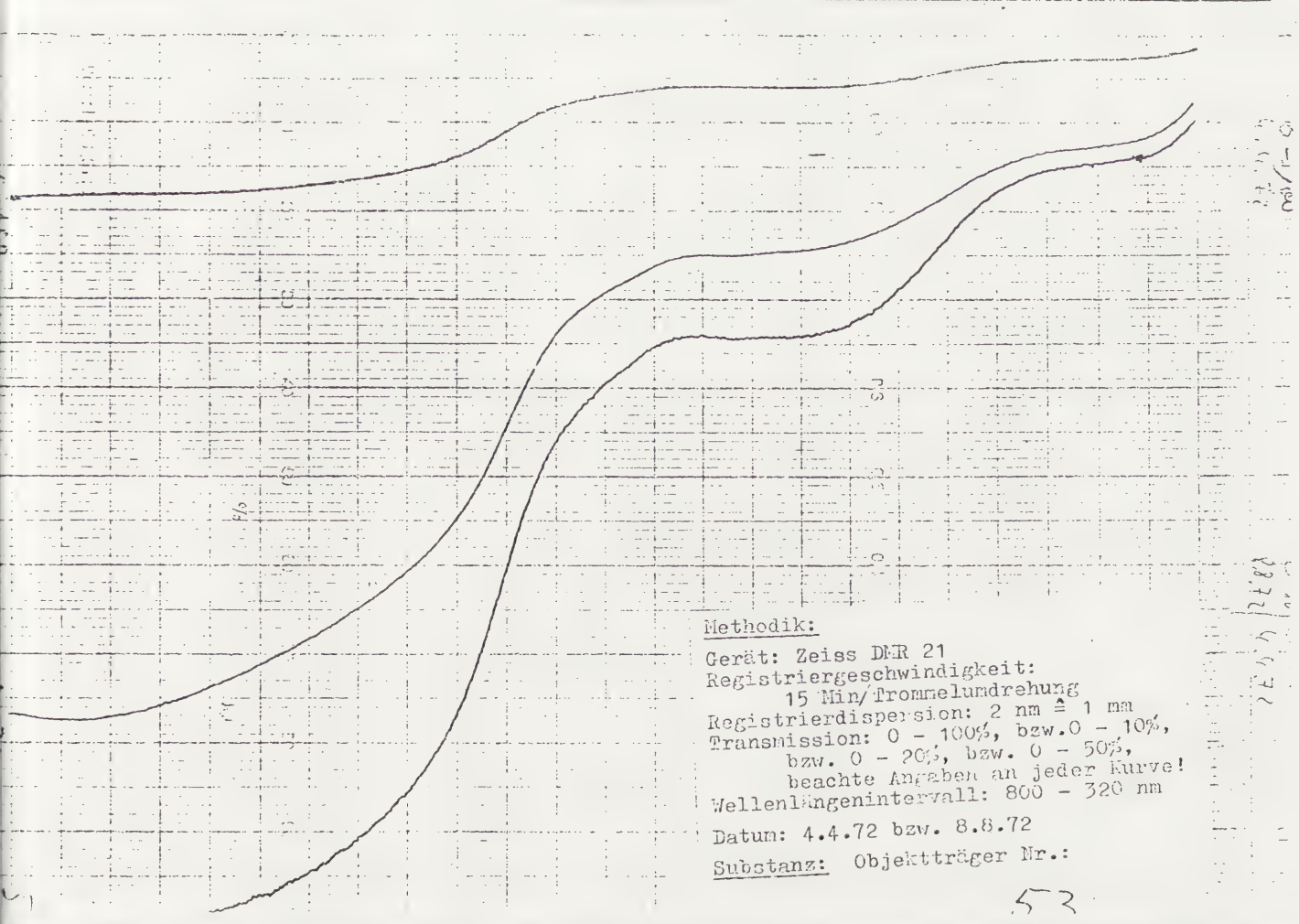

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beachte Angaben an jeder Kurve!
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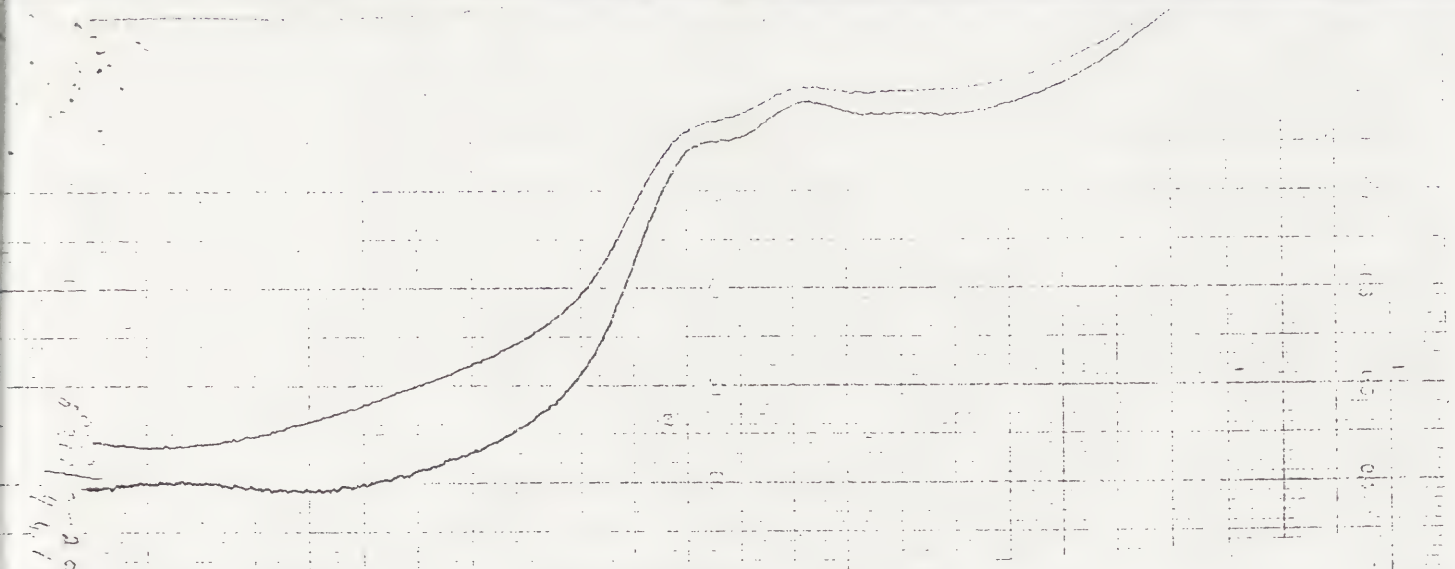

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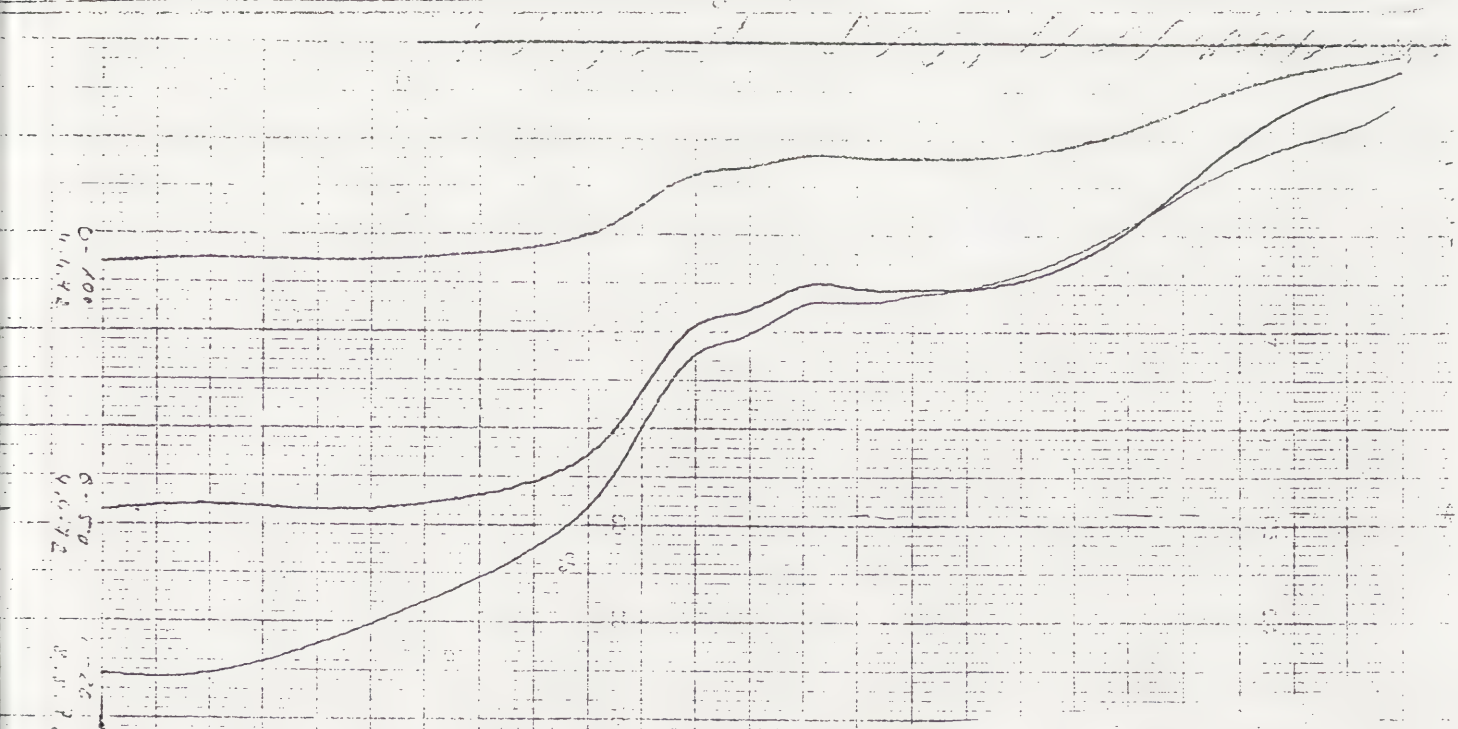

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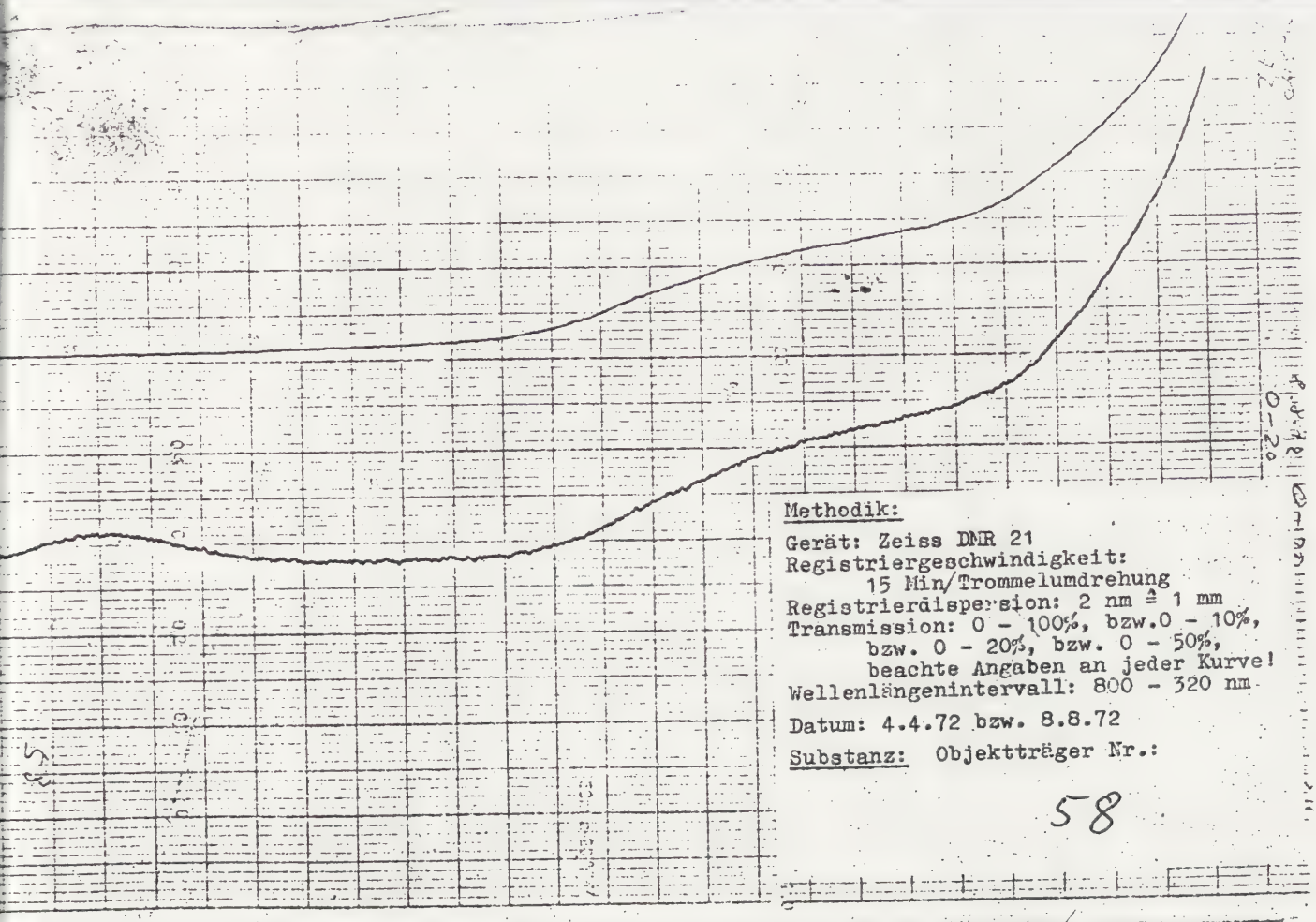
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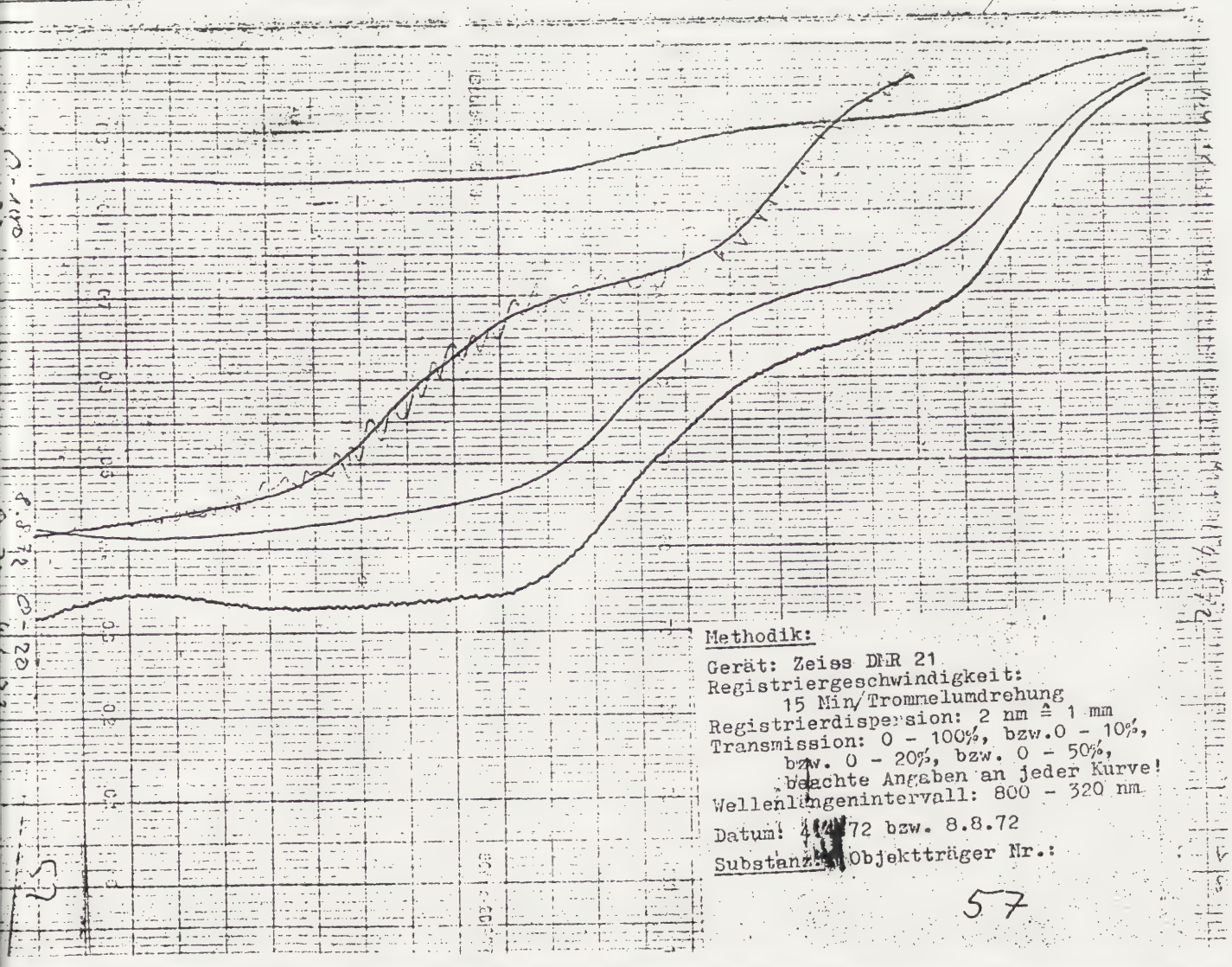
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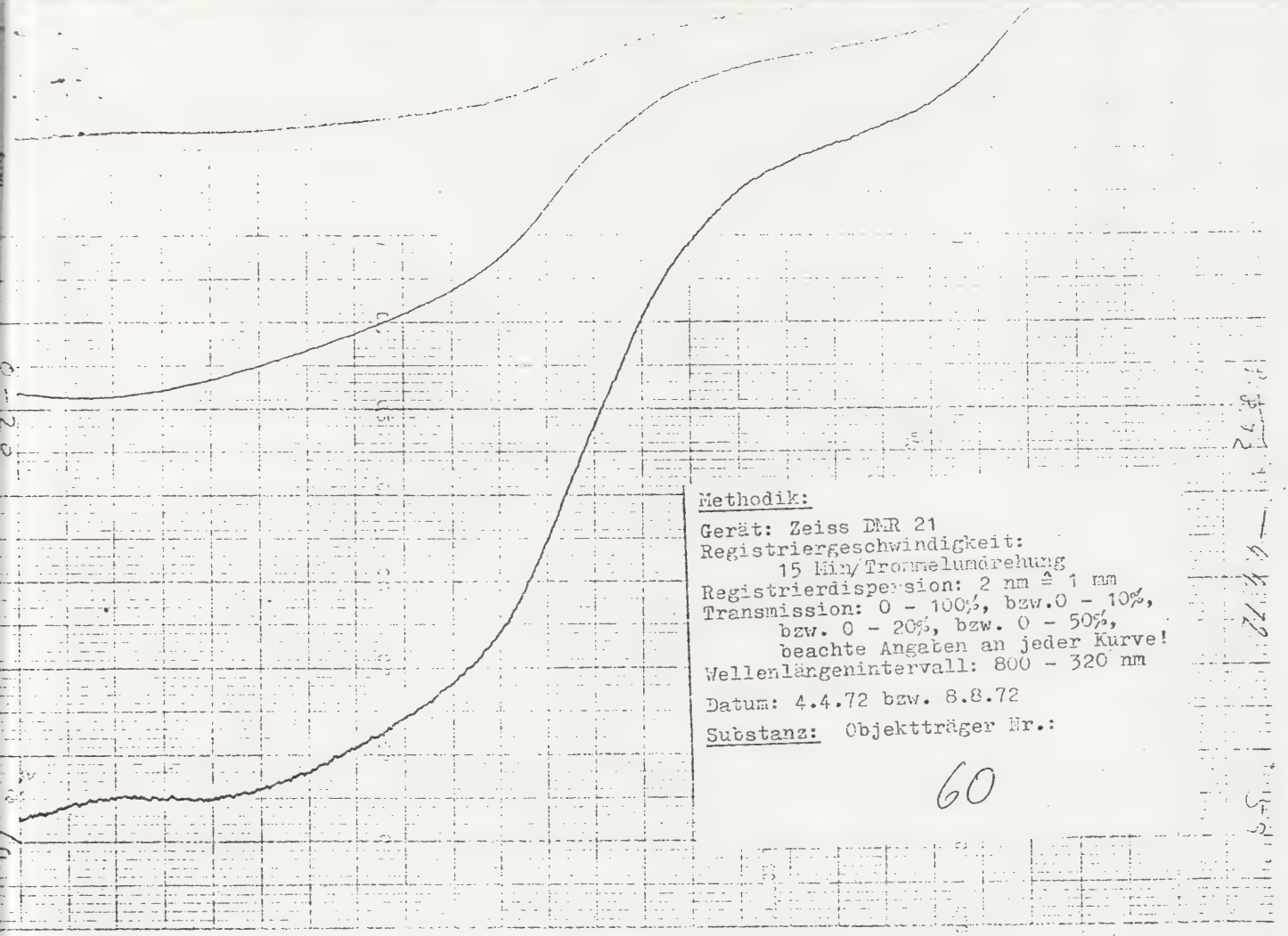
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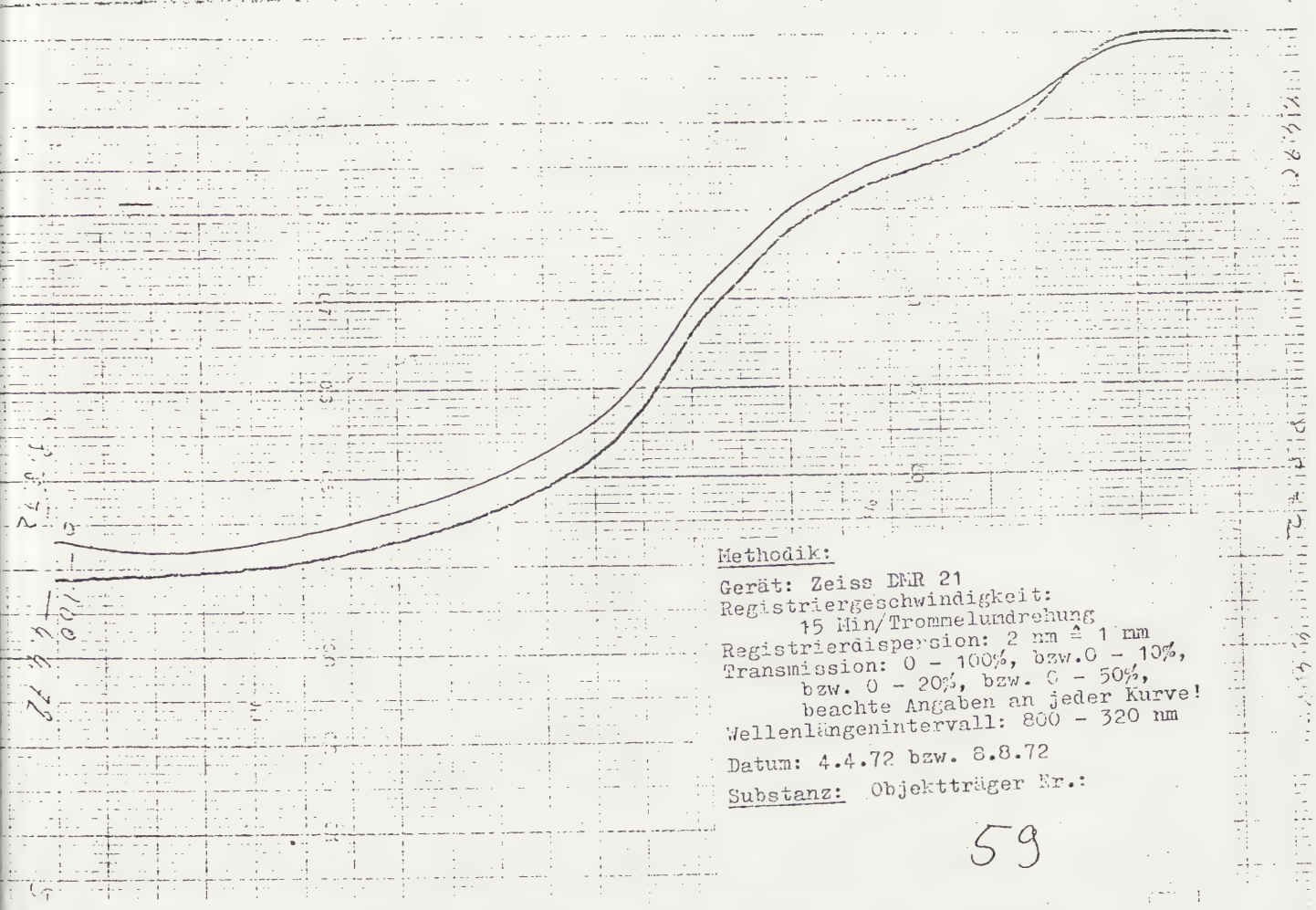
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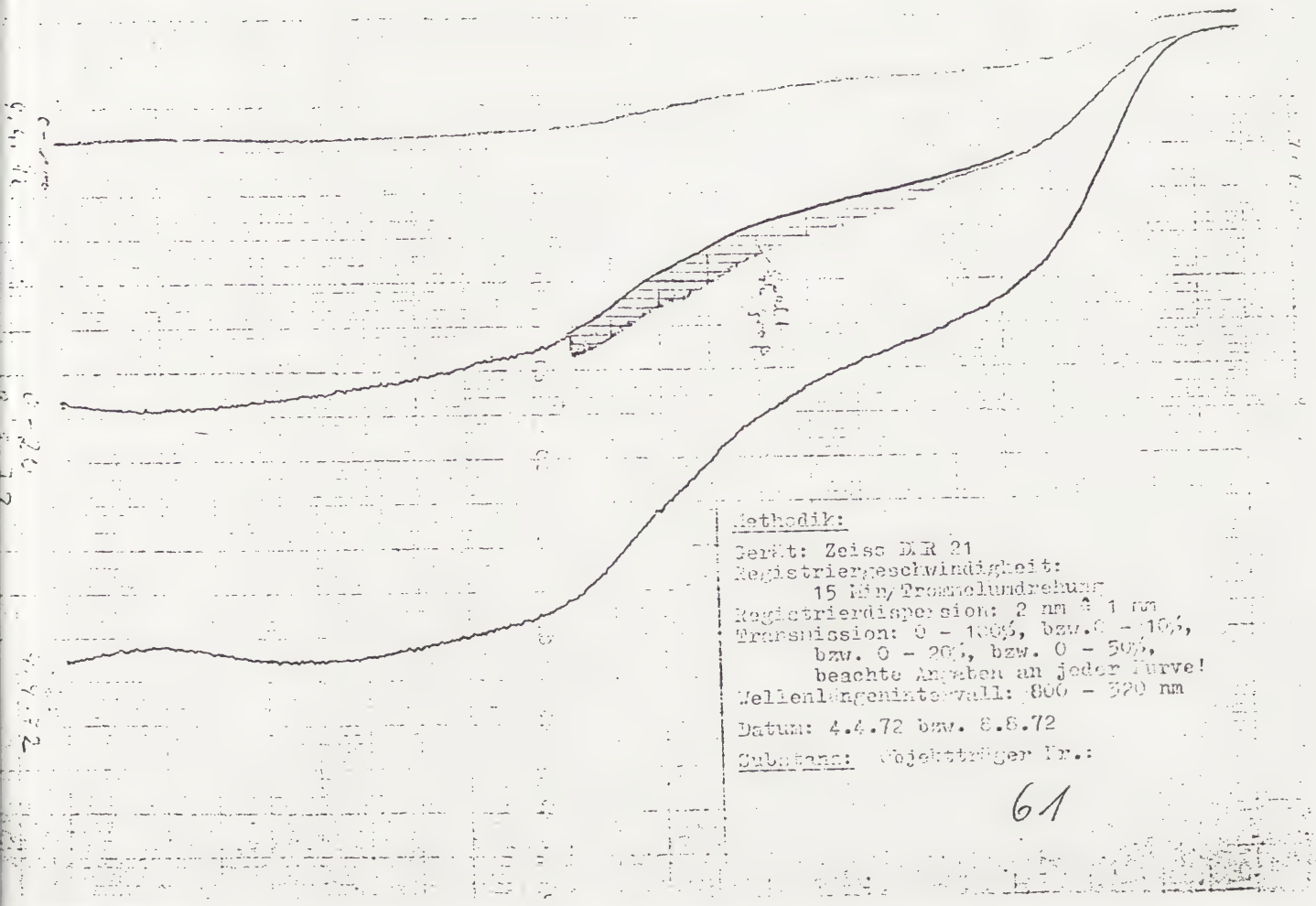
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9/2

COMMITTEE FOR CONSERVATION

3th Plenary meeting

MADRID

2 - 7 Octobre - 1972

8981 98

Vera Radosavljević dipl.ing.
Narodna biblioteka, Beograd

CONSERVATION OF MINIATURES

Introduction

The Laboratory for Conservation of the National Library of Serbia has been during the recent years often recieving demaged illuminated manuscripts. The damages were most often on the supports which were under the green colours. They were thinned, perforated or completely disappeared, in the worst cases. There was no problem in the conservation of the sheets, however the conservation of the miniatures was always postponed for the simple reason that there was not confidence enough in any of the already used agents that it would fulfill all the required conditions - not to alter the appearance of the miniature, to bind well, not to harm pigments and media used in painting and to be elastic and durable.

For that reason some preliminary tests were performed to establish, first, why the damages were always under the green colours (malachite and verdigris), and second, to find out the agent which could be used best for fixing the weakly bound paint layers.

Literature data

Before we started with practical work which could not be completely performed in the old and unappropriate building of the Library, a large number of treatises were studied on preparing paints for painting miniatures, i.e. tempering of pigments with different media. The tracts were of European origin (Western countries, Bisanthine, Russia and Serbia) as well as from the Near East.

It was established that the most often used natural mineral pigments were cinnabar, ultramarine, azurite, malachite, orpiment, ochres and the artficially made mineral pigmemts vermillion, minium, verdigris and white lead. The most often used natural organic pigments were kermes, cochineal, pigments from Brazil wood, campeachy wood, sandalwood, iris-green, sap green, indigo, folium, saffron, gall of oxen or big fishes and pigments made of some other plants growing in the countries where they were used. The most often used metals were gold and silver. Tin lead and mercury were used as substitutes when there was not any gold or silver.

The used media were always the same: gums, glair, gelatine, rarely rezins, yolk and casein only exceptionally. The media were at first used pure, later they were increasingly used mixed. The exception was verdigris which was very often mixed with vinegar regardless of the region it was used in.

Additives to the media that served to maintain the elasticity of the paint layer were also the same: honey, sugar, candy, euphorbia juice, figs and pomegranate juice. Realgar, camphor, sal ammoniac and alum served to prevent putrification.

No essential differences in the pigments production were established except for verdigris which was produced only of vinegar in the West, while in the Near East, in Russia and Serbia it was produced also with sour milk, which gave a product of different chemical composition and different colour, very similar to malachite.

The techniques of painting were always the same or almost the same.

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*-Selected recipes and examples through centuries from Eastern and Western countries were classified and most of them experimentally controled. They will be published with comments at the beginning of 1971

Experimental work

In order to establish what kind of verdigris is the most harmful and under what conditions the parchment is mostly being damaged, 10 percent solutions of verdigris were prepared in water and vinegar (obtained from wine that was left for one month in an open bottle, pH 1,6). Also, a dispersion of malachite was prepared by putting 10 g of powdered malachite into 100 g of water.

Into these solutions i.e. into the malachite dispersion equal pieces of parchment were immersed for 6 hours and then dried on 45°C.

The following results were obtained:

Table 1.

No.	Solution	pH of the solution	Condition after 96 (16x6) hours of immersion and 16 successive dryings
1.	Verdigris prepared of vinegar and copper solution in vinegar	3	Completely thinned, but whole
2.	Verdigris prepared of vinegar and copper, solution in water	6	With no evident changes
3.	Verdigris prepared of salt, honey, vinegar and copper, solution in water	3,5	Very thinned and perforated in several places, similar to the damages on manuscripts

4.	Verdigris prepared of sour milk and copper, solution in water	6,2	No evident changes
5.	Natural malachite in water	7	With no evident changes

These results confirmed the theoretical hypothesis that the used vinegar or wine instead of binding media were the main cause of parchment damages.

Wine and vinegar are also the answer why the green paints disappeared from the manuscripts while all the other paints were intact. They could not remain when the used verdigris was mixed only with vinegar or wine.

The most drastic cases were those with the parchment supports completely perforated in the places where green paints previously were, and which lately became partly brown. This can be explained by the use of Spanish green* (in spite of the tracts recommendations that it should not be used). The reaction between sugar from honey and copper salts gives brownish cuprous oxide, and besides that the Spanish green is most harmful.

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* Verdigris prepared of salt, honey, vinegar and copper.

The pH value of the water with the dispersed malachite as well as the fact that the parchment was not evdently damaged after immersion in this water, lead to the conclusion that the parchment was not damaged by malachite, but that the places where we can today prove the presence of copper carbonate were painted with verdigris which gradually changed into carbonate, either because of the contact with chalk which could be found in the parchment, or by contact with carbon dioxide from the air, for it was not protected with binding media.

These experiments will be continued in order to establish the influence of different substances (gum, parcley, saffron, iris green etc. added to verdigris in painting on the destruction of support and damaging of the paint layer.

The second part of the experiments was started in order to establish the binding power of the substances most often used for fixing miniatures on paper andparchment, as well as several solutions that were also used, according to the medieval treatises to temper pigments for illuminations.

Those were glair; glair mixed with water in different proportions with or without the addition of honey; glair in different mixtures with gum arabic, with honey or without it; different concentrations of gum arabic with the addition of extracts of saffron and parcley or without them; gelatine, vinegar, wine, different concentrations of methyl cellulose and soluble nylon.

Samples of tempera prepared from various kinds of verdigris and of the cited solutions were applied with a brush on parchment without mordant and on paper. Some of the samples were then aged for 20 hours under an UV lamp while the others were not aged.

After that all samples were in the course of four years, from time to time, moved from place to place and turned

like sheets of a book.

The appearance they had after that is described in the table 2.

From the obtained results it can be concluded:

1. All used media gave much better results in all cases on paper than on parchment without mordant This practically means that when the fixatives are being selected it should be considered whether they would be used on parchment or paper.

2. The 5 percent gelatine gave the best results among the natural media.

3. The best results of the artificial media were obtained with 2% soluble nylon.

4. The composition of verdigris played a definite role in binding, as verdigris prepared of sour milk tempered with wine was well bound, surely because of the casein it contained.

5. Honey had a definite role, too, because of its hygroscopy, i.e. its property not to permit drying of the paint layer.

6. The quantity of honey in the tempera had to be very minute or the change in colour occured.

These investigations will be contnued with the same and new media under different conditions of aging.

Table 2

No.	Pigment	Medium	The result (appearance) after 4 yers of handling without artificial aging		The result (appcearance) after artificial aging and 4 years of handling	
			paper	parchment	paper	parchment
1.	Verdigris *	glair : water 1 : 1	good	fairly good	good	paint layer flaked off
2	Verdigris	glair : water 1 : 2	good	good	good	flaked off
3.	Verdigris	glair : water 1 : 3	good	good	good	flaked off
4	Verdigris	glair : water 1 : 4	good	good	good	flaked off
5	Verdigris	glair : water 1 : 4 some drops of honey **	well bound but darkened	well bound darkened	well bound darkened	well bound darkened
6	Verdigris	glair : water 1 : 4 a little more honey	well bound darkened	well bound darkened	well bound darkened	well bound darkened

* Made of vinegar and copper. if not other data given.
** Given quantities of honey were always added to 10 ccm of the solution.

Table 2

No	Pigment	Medium	The result (appearance) after 4 years of handling without artificial aging		The result (appearance) after artificial aging and 4 yers of handling	
			paper	parchment	paper	parchment
11	Verdigris	glair:water:gum 1 : 4 : 2 2 drops of honey	well bound, colour changed to brownish-green	well bound, colour changed to brownish-green	vell bound, changed to green	flaked off
12	Verdigris	glair:water:gum 1 : 4 : 3 3 drops of honey	well bound, darkened	vell bound darkened	well bound, darkened	well bound darkened
13	Verdigris	gum arabic 4% solution in water	good	good	good	flaked off
14	Verdigris	gum arabic 4% solution + 2 drops of toney	well bound, colour changed to brownish-green	well bound changed to brownish-green	well bound, changed to brownish-green	partly flaked off
15	Verdigris	4% gum arabic	good	almost good	good	flaked off
16	Verdigris	5%gum arabic	good, colour changed to green	good, changed to green	good, changed to green	flaked off

Table 2

No	Pigment	Medium	The result (appearance) after 4 years of handling without artificial aging		The result (appearance) after artificial aging and 4 years of handling	
			paper	parchment	paper	parchment
7	Verdigris	vinegar	flaked off	flaked off	flaked off	flaked off
8	Verdigris	glair : water: gum 1 : 4 : 1	good	fairly good	good	flaked off
9	Verdigris	glair:water:gum 1 : 4 : 2	good	fairly good	good	flaked off
10	Verdigris	glair:water:gum 1 : 4 : 2 + drop of honey	well bound, colour slightly changed to green	well bound, colour slihtly changed to green	well bound, colour changed to green	flaked off

** * Gum arabic was atwoys used.

Table 2

No.	Pigment	Medium	The resut (appearance) after 4 years of handling without artificial aging		The result (appearance) after artificial aging and 4 years of handling	
			paper	parchment	paper	parchment
17	Verdigris	1,5% methyl cellulose	good	fairly good	good	flaked off
18	Verdigris	1% methyl cellulose	good	fairly good	good	flaked off
19	Verdigris	0,5% methyl cellulose	good	partly flaked off	good	flaked off
20	Verdigris	soluble nylon 2%	good	good	good	good
21	Verdigris	wine	flaked off	flaked off	flaked off	flaked off
22	Verdigris	parcley juice	good, changed to leaf green	good, changed to leaf green	good, changed to leaf green	good changed to leaf green

TABLE 2

No	Pigment	Medium	The result (appearance) after 4 years of handling without artificial aging		The result (appearance) after artificial aging and 4 years of handling	
			paper	parchment	paper	parchment
23	Verdigris	pure juice parcley	pale grimish	pale grimish	pale grimish.	pale grimish
24	Verdigris	gum 14% + softron	good green	fairly good green	good. green	flaked off
25	Verdigris made of sour milk	glair : work 1 : 1	good	good	good	flaked off
26	Verdigris made of sour milk	glair : water 1 : 2	good	good	fairly good	flaked off
27	Verdigris made of sour milk	glair : water 1 : 3	vairly good	bad	flaked off	flaked off
28	Verdigris made of sour milk	wine	good	good	good	fairly good

Table 2

No.	Pigment	Medium	The result (appearance) after 4 years of handling without artificial aging		The result (appearance) after artificial aging and 4 years of handling	
			paper	parchmant	paper	parchment
30	Verdigris made of sour milk	glair gum:water 1 : 1 : 1 drop of honey	good	good	good	fairly good
31	Verdigris made of sour milk	2%methyl celulose	good	good	good	fairly good
32	Verdigris made of sour milk	0,5% methyl cellulose	good	good	good	fairly good
33	Verdigris made of sour milk	2% soluble nylon	good	good	good	good
34	Malachite	glair water	good	good	good	flaked off
35	Malachite	glair water 1 : 1	good	good	good	flaked off
36	Malachite	glair water 1 : 2	good	good	good	flaked off

Table 2

No.	Pigment	Medium	The result (apperance) after 4 yers of handling without artificial aging		The result (appcearance) after artificial aging and 4 years of handling	
			paper	parchmant	paper	parchment
37	Malachite	glair gum wotre 1 : 1	good	good	flaked off	flaked off
38	Malachite	glair: gum : gum 1 : 1 : 1	good	good	good	flaked off
39	Malachite	methyl cellulose 1%	good	good	good	fairly good
40	Malachite	2% soluble nylon	good	good	good	flaked off
41	Malachite	water : gum 1 : 1 drop of honey	good	good	good	flaked off
42	Malachite	water:gum:glair 1 : 1 : 1	good	good	fairly good	flaked off

Table 2

No.	Pigment	Medium	The result (appearance) after 4 yers of handling without artificial aging paper		The result (appearance) after artificial aging and 4years of handling	
			paper	parchmant	paper	parchment
43	Verdigris	5% gelatine	good	good	good	good
44	Verdigris	5% gelatine some drops of honey	well bound, but braon	well bound, but braon	well bound, but braon	well bound, but braon
45	Verdigris made of sour mik	5% gelatine	good	good	good	flaked off
46	Verdigris made of sour mik	5% gelatine + some drops of honey	good but grinish-brown	good but grimish-brown	good but grimish-brown	flaked off
47	Malachite	5% gelatine	good	good	good	fairly good
48	Malachite	5% gelatine some drops of honey	good	good	good	fairly good

CONSERVATION OF MINIATURES

SUMMARY

The work on the conservation of miniatures was carried on in three directions;

1. The theoretical studies of miniature painting technique of the Middle Ages through the old recipes from Western Europe, Russia, Serbia and the Near East countries.

This work has been completed with conclusion that there were no essential differences in the technique of painting between these countries, considering the recipes that have been studied.

2. The theoretical presumption that vinegar is the cause of frequent damages under the green colours has been verified by experiments. These experiments will be continued in order to establish the influence of some materials mixed with verdigris (such as parcley, iris green etc.) upon the velocity of the reaction.

3. The binding power of substances used for fixing miniatures as well as several solutions used for tempering pigments in illumination was tested in order to establish their convenience for the use on parchment and paper.

The results were always better on paper than on parchment (without mordant). The best results were obtained with 5 percent gelatine among the natural media and among the artificial - ones 2 percent soluble nylon; the composition of verdigris also played a certain role, as the verdigris prepared of sour milk was bound well with pure wine; honey improved binding but changed colour if there was too much of it.

The experiments will be continued with the media used in the Middle Ages but under changed conditions of drying.

3/-1

The International Council of Museums
Committee for Conservation

Conseil International des Musées
Comité pour la Conservation

Madrid: October 2-8, 1972

G.Z. Bykova, A.V. Ivanova, I.P. Mokretzova

CONSERVATION METHODS FOR MEDIEVAL MINIATURES ON PARCHMENT

The illuminated manuscripts on parchment form a significant group among the artistic monuments of the Middle Ages. In the same manner as the other medieval objects of art they need constant attention from the restorer. But the treatment of a miniature painting is still an unsolved problem, although there are some effective methods for the conservation and "straightening" of the parchment and leather book-binding. By "conservation" of miniatures we mean only the treatment of the paint layer. It is out of the question to make any retouchings.

Some technical data on the miniature-painting

The treatment of a miniature painting in the manuscripts in our Laboratory was preceded by detailed study of its technique, not only the theoretical aspect (by studying the medieval treatises), but also by examining numerous illuminated manuscripts in the collections of Moscow, Leningrad, Yerevan, Tbilisi and some other cities in the USSR. All sorts of destruction found in manuscript painting were revealed in the course of this examination.

All manuscripts written on parchment, according to their technique and the state of preservation can be divided into two groups: the first group consists of illuminated manuscripts produced in Western Europe (as well as a part of Western Slav and some Old Russian manuscripts with miniatures) and is notable by the relatively good

state of preservation. The other group includes Byzantine and similar to them technologically Old Russian, Georgian, Balkan, partly Armenian illuminated manuscripts, miniatures of which are badly preserved.

Our information, concerning the technique of the Byzantine miniature painting, is near to nothing in comparison with West-European book illumination, the materials and techniques of which are described in many medieval treatises. Practically the only Greed treatise on the painting technique, that we know, is "Herminia" by Dionisius of Furna, written in XVIII century. But it does not contain any direct information concerning the technique of miniature painting. That is why for reconstructing the methods of Byzantine miniaturists one is obliged to deal with diverse historic documents and technological treatises, compiled in countries, where the technique of the book-painting was alike to that of the Byzantium. 1)

The notion about technological methods of the Greek manuscript-artists can be also obtained during the examination of numerous flakings of the paint-layer, that reveal the original drawing and underpainting. All the same, it is obvious, that the West-European and Byzantine painters (as well, as Old Russian, Georgian, Armenian, etc.) used the same mineral pigments - cinnobar, white and red lead, malachite, copper green, lapis-lazuli, azurite, auripigment, ochres, etc. Red-rose lakes were widely applied as well, as other pigments of organic origin. For media the white of egg and some sorts of gummi were used, and in some exceptional cases - the yolk of egg, parchment glue and even isinglass.

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1) Some information on pigments, used by Byzantine miniaturists is contained in books and articles by A.P. Laurie (for example, see his "Ancient pigments and their identification in works of art". - "Archaeologia", vol. LXIV, 1913, and subsequent works.)

Technological methods of Byzantine and occidental manuscript-artists were characterized by opposite tendencies: Greek miniaturists were distinguished by purely "pictorial" methods of work, analogical to that of the icon or, fresco-painting, when the colours were superimposed many times. [1] The West-European illuminators (up to the middle of the XIVth century) utilized a "colouring" method, where modelling and chiaroscuro were expressed by graphic manner.

The contours of the composition (figures, ornament, numerous folds on garments, etc.) were in general outlined in ink and that increased the flatness of objects presented.

A great role in Western book illumination as well as in Byzantine miniatures was assigned to the gold (the leaves of gold). Occidental masters layed their gold on specially made preparation - very thick layer, consisting as a rule of chalk, mixed with strong glue (probably isinglass or parchment glue), red clay (armenian bolus, for instance) or simply with any pigment. Byzantine miniaturists applied golden leaves immediately on the parchment, coated by strong glue (isinglass or parchment glue), sometimes mixed with a red pigment (cinnobar).

Very thick and compact ground of western illuminators gave them good opportunity to polish the gold, layed on it. Its brilliant surface after polishing had the appearance of metallic golden objects. [2]

---

1) Comparatively detailed description of Byzantine miniature technique is given by C. Diehl (Manuel d'art byzantin, t. 2, Paris, 1926, pp. 600 - 601.)

2) An exception to the rule was the gold of Italian miniaturists of the XIV-XV centuries. Resulting from some technological error, it is preserved in much poorer state than the paint-layer - the golden surface is covered by numerous small cracks, and particles of it flake away together with thick and brittle ground.)

The gold of Byzantine miniaturists which covers as a rule a greater part of a composition, than in occidental illuminations, on the contrary, was layed on a very thin ground. Often it reproduces the texture of a parchment, which sometimes is wrinkled and that gives the impression of a "crumpled" surface. 1) The thin ground could not give much possibility for the miniaturists to polish golden surface well enough, so it has a rather lustreless appearance.

If the West-European illuminations are characterized by a clear-cut division of sections, covered by gold and by colours, the Byzantine miniatures are often painted directly on the golden background. Therefore, one can make a conclusion: Western illuminations are characterized by rather thin paint-layers, while the gold is placed on a very thick ground. On the contrary, in Byzantine miniatures the gold was layed on a thin ground, whilst the pigments, superimposed many times, formed a layer, thickness of which had much excelled that of the Western painters.

The notorious bad preservation of the Greek and analogical to it book-painting can be explained not only by the considerable thickness of the paint-layer, but by a weak cohesion of it with the parchment. The West-European and Greek manuscript-painters had got for their work the material - parchment - same by nature and name, but opposed by its qualities: occidental parchment-makers in their final operations pumiced the parchment and rubbed chalk into it. That made the surface look velvety and lustreless, and led to the better absorption of pigments and ink. On the contrary, the Greek masters thoroughly polished their parchment

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1) The continuous golden background of Byzantine miniatures in reality consists of numerous, sometimes rather small leaves of gold. It is easily seen, while placing the parchment with the miniature against the light.

and made its surface look brilliant by treating it with the white of egg and flax-seed. [1] That is why the thick paint-layer of Greek miniaturists does not have enough force of adhesion with the parchment and is easily tended to flake away (Fig. 1). [2]

The forms of destruction in the medieval book-painting

Thus we can see, that the principal cause of flaking of the paint-layer from the Byzantine miniatures is the properties of the parchment. That conclusion can be confirmed by the next visual example: in one of the manuscripts from the Leningrad Public Library (Gospels of Demetrius Paleologus, gr. 118) all miniatures painted in different periods (XIV, XVI and XVII-XVIII centuries) and in different manners but on the same parchment, are equally flaking away. It is quite possible that the paint-layer of Byzantine miniatures began to flake away soon after their execution (maybe one or two hundred years later). This is confirmed

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1) There exists very scarce information concerning the production of parchment in Byzantium (see, for example, R. Devréesse. Introduction à l'étude des manuscrits grecs, Paris, 1954, pp. 13 - 14. But relatively thorough information on the subject can be extracted from medieval Armenian receipts. In one of the next issues of "The Proceedings of WZNILKR" ("Soobstchenija WZNILKR") some of them will be published. Some detached receipts concerning the parchment production in Medieval Europe can be found in articles by D.V. Thompson. The complete manual on the subject was published in XVIII century by J.J. Lalande ("L'art de faire le parchemin", s.l.s.d.).

2) That was noted by A.P. Laurie (op. cit., p. 331) and O.M. Dalton (East Christian Art. Oxford, 1925, p. 298).

by their earliest "conservation" treatments, in some cases expressed by retouchings, in others - even by attempts to strengthen the paint-layer. 1)

For Byzantine miniature painting are typical the same kinds of destruction as for distemper painting: exfoliation and pulverization of the paint-layer, its "peeling". Apart from it, as was said above, it is typical for Byzantine miniatures to be painted on the golden background. The polished golden surface cannot retain the thick paint-layer and it flakes away as easily, as from the parchment. The leaves of gold are fixed on the parchment much better than the colours, but it often happens that the gold "peels" and flakes away in the same manner as the paint-layer. One more phenomenon may be noted: in Greek manuscripts parchment was ruled not by pencil or a pen, but was "pressed", through by a spike. And the paints often flake from such "reliefs".

The destruction of occidental medieval book illuminations depends more or less on casual circumstances. For example, in French and Mosan manuscripts of the XIII-XIV centuries, executed marvellously from the technological point of view, notwithstanding the general fine state of preservation, one may see flaked and pulverized ceruse. Among the French and Flemish manuscripts of the XV-XVI centuries there are some of mediocre execution, where the relatively thick paint-layer flakes away, because of some technological error. The flaking of gold in Italian manuscripts was mentioned already.

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1) In the Demetrius Paleologus Gospels (Leningrad State Public Library, gr. 118) the retouchings are seen in XIV century miniatures. Maybe they were made at the same time as the miniature cycle of the XVII-XVIII centuries in this manuscript.

In another manuscript (Leningrad State Public Library, gr. 305, Tables of Canons) the transparent strips may be seen on the parchment and on the paint-layer itself. That is the result of obvious attempts to attach the "peeling" paints to the parchment.

Amongst the frequent damages in occidental manuscripts should be noted the "imprints" of illuminated fragments on the page opposing the other with the original. Probably, it is an influence of moisture.

That phenomenon is practically irreversible, because it is impossible to remove that "imprint" without damaging it from the parchment, as the force of the cohesion of the "reversed" paint-layer with new ground is too great; and it appears impossible to restore such fragments to their proper place.

While the destruction of paint-layers in occidental manuscripts is more or less casual, the good preservation of Greek miniature paintings seems to be rather uncommon business. The flakings of the paint-layer are sometimes so numerous, that only insignificant traces are left from the miniatures.

It is necessary to mention a deformation of the parchment, provoked by different causes. That also gives way to the destruction of the paint-layer.

Therefore it is obvious that the conservation problem of medieval manuscript painting is a problem of treatment of flaked and pulverized paint-layers, as well as flaked fragments of gold. In the first place, it is urgent for Byzantine manuscripts and a group that is similar to them.

The treatment of miniature painting in WZNILKR

In our laboratory the conservation practice was preceeded by labour-consuming experiments, accompanied by manufacturing many sorts of samples for selection of the best materials for the treatment and elaboration of technological methods. At first, we applied for the samples an old mackle parchment. Then in one of Moscow's scientific institutes a new parchment was manufactured. It was a material of different qualities: some of the sheets had velvety surfaces; others were glossy. They differed also in colour and thickness. In general that parchment

recalled by its texture and properties the Byzantine material (it was treated with the extract of flax-seed - the method probably used by Greek parchment-makers).

The colours used in these samples were prepared after the medieval receipts. Only mineral pigments were applied: ochres, azurite, lapis-lazuli, cinnobar, white and red lead, auripigment, malachite, chrysocolla. For media the white of egg and gummi (from cherry trees and gummi-arabic) were used.

Diminishing the quantity of medium in colours, we obtained in our samples the destruction similar to those that can be seen in medieval manuscripts. Thus the preparation of these samples was a necessary stage in our work, especially for the selection of the materials. The technological requirements to this material were approved by the Conservation Council of the laboratory. On the basis of these requirements a few groups of polymer materials were selected and tested from physico-mechanical and chemical points of view. The materials which showed the best indices and technological properties were recommended and instilled into the conservation practice. After testing a considerable number of compounds, it was decided to dwell on two of them: the soluble fluorine plastics (ftorlon 26L and ftorlon 6H) and aqueous dispersion of copolymer of vinylacetate with 2-ethylgexilacrylate (VA 2 EGA). All kinds of destruction in the manuscript painting can be divided in two groups: pulverization of the paints, deprived of the medium, and flaking of the paint layer. In the first case a consolidation of it is needed, in the second - the glueing of it to the parchment.

Depending on the character of the destruction one of the said materials is used. The films on the base of fluorine plastics are recommended only for the consolidation of the pulverized paint-layer. VA 2 EGA - compound distinguished by high elasticity and adhesion, proved to be especially effective for adhering numerous fragments of flaking paint to the smooth and deformed parchment.

VA 2 EGA is easily prepared, it dissolves in water in any proportion. It is necessary to work with the freshly prepared compound (not more than three days old). While working it is important to keep the compound clean. To obtain the surface, that would tend easily to moistening, it is necessary to treat the paint-layer with spirit and water solution (1 : 1). VA 2 EGA is applied on the surface by a thin kolinsky-brush. The concentration of the solution depends on the thickness and compactness of the destructed paint-layer (up to 5%).

The conservation practice was started on the most convenient material - the illuminated charters and fragments from manuscripts.

We began the treatment of Byzantine miniatures in 1967. The damaged manuscripts came from the Manuscript Department of the Leningrad State Public Library. At first, the remains of miniatures in some detached parchment fragments (gr. 379, gr. 305) were treated.

Then there was serious conservation treatment of the so-called Trebizond Gospels (gr. 21, IX-X century). This manuscript consists of separate parchment leaves with text and miniatures, which were bound together in the middle of the last century. According to the technique and state of preservation, all 14 miniatures of these manuscripts can be divided into two groups. The first group is characterized by relatively thin and compact paint-layers, which contain rather small amounts of white lead. The miniatures of this group are generally well preserved. Some damages may be seen on the ornamental border, and there are some insignificant "peelings", seen on the surface of the paint-layer. The second group is characterized by a soft and dim colour scale. The rosy, purplish and greenish hues were obtained by mixing the pigments with considerable amounts of white lead. For this reason there are some quite serious destructions of the paint-layer. For that group of miniatures are typical pulverization, swelling and flaking of the paint-layer. That is the cause for a lot of lacunes on the miniature's surface. Some of the miniatures have washed out and have a somewhat lustre appearance, provoked by many centuries of utilization of the manuscript.

Taking all that into consideration, the approach to the treatment of each miniature was individual. The parts with relatively compact paint-layers, which only tended to flake away from the parchment, were treated with a 3% solution of VA 2 EGA (generally the miniatures of the "first group"). There were no surprises, the reinforcement turned out to be firm enough and no change in colour was observed.

The miniatures of the second group presented more difficulties. There the treatment was more complicated. The sections with thin and friable paint-layers, which had not yet flaked away were treated by ftorlon 26 L (1% solution, two or three impregnations). The compound was easily absorbed by the destructed paint-layers. Growing soft it "occupied" the original place and adhered to the parchment.

More complicated problems appeared during the treatment of miniatures of the XIIth century Greek Gospels with Apostle (gr. 101). [1] The XII century miniatures of that two volume manuscript were repainted in the XIII century, after the remains of the original had been covered with very thick ground so that in some parts the parchment was even thinner than the paint-layer (v. 1. f. 10v°, St. Matthew). This fact as well as incorrect binding in the XVIII century had provoked a considerable deformation of the parchment. All that appeared to be the reason for serious destruction of paint - and gold - layers, placed on a very thick ground. It was decided to treat these miniatures with aqueous dispersion of VA 2 EGA, which is distinguished not only by very good adhesive properties, but practically does not cause any shrinkage.

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1) See Y. Grenberg and I. Mokretsova. L'étude et l'attribution des miniatures de l'Evangile byzantin faisant partie de la collection de la Bibliothèque nationale publique Saltykov - Chtchédrine. "Conseil International des musées. Comité pour la conservation". Amsterdam, 13-19 septembre, 1969.

The treatment was carried out as follows: at first was liquidated the deformation of the parchment caused by the binding. It was done by local moistening and pressing (the small sandbags were used). The the paint-layer was treated by 5% VA 2 EGA (one or two impregnations with instilling under the unusually thick parts a 10% compound). Under the stiff flaking parts a compound of weak concentration was at first infused for the softening of the paint-layer. After that a more concentrated material was used for adhering the paint-layer to the parchment. After drying the surface a small sandbag was placed on the treated section for more safe adhesion of flaking paints to the parchment and for straightening the small deformations of the parchment, if there were any. After the treatment the miniatures were kept for a month in natural conditions for stabilization of the compound. Then the parchment was straightened. For that purpose we adopted the method of "distant moistening", which is practicized at the Conservation Department of the Leningrad State Public Library. The deformed parchment with thick paint-layers was moistened by a spirit-aqueous solution (in proportion 1 : 1). The most deformed parts of the parchment were straightened beforehand by local weight. The principal danger in "straightening" the parchment with miniatures lies in a fact, that softened and pressed paint-layers may loose their texture and get flattened. That is why we do not recommend utilizing the polygraphic press, which is used commonly in graphic conservation departments. We straightened the deformed parchment in the following way: the cheesel-cloth folded in two was moistened by a spirit-aqueous solution (1 : 1), then it was wrung out strongly and placed on a non-absorbing surface (glass, plastic, plexiglass). On this surface six sheets of filter paper were layed and on them a parchment leaf with a miniature turned upwards (when the miniature is painted on one side of the leaf). The treated miniature was covered by wax-paper and then by plexiglass. By this method it is easy to attain the even and relatively low moistening of the entire sheet of parchment. The time for the moistening cannot be the same in different cases. Depending on the thickness of the parchment and the character of its deformation, it may be equal to 1,5 - 2 hours. During the process a constant control is needed. One should be careful to stop the moistening at the

moment, when the parchment itself would be moistened as much as possible. The paint-layer should not get damp, because it can become deformed after the pressing.

After softening, the parchment must be placed first between two sheets of wax-paper and then, between several sheets of filter-paper. Before putting weight on it, it is necessary to straighten all wrinkles and other deformations. As a weight, the best thing is to utilize sandbags and, if there is any need, to place the additional weight upon them. Then, an even pressure on the whole surface occurs and the paing-layer cannot be harmed.

The treated parchment-leaves are kept under the weight for two-four weeks with regular changing of the filter-paper. Parchment with miniatures on both sides of the leaf must be treated more carefully.

In two weeks time, after placing the parchment under the press, it is necessary to inspect the condition of the paint-layer and to strengthen it again, if there is any need.

The best way to keep detached straightened parchment leaves before binding, is to place them in a specially made case (two wooden boards tied by leather straps). That should be done to avoid the possible deformations during the changes of the temperature and humidity.

Therefore for the treatment of the miniatures we may recommend the fluorine plastics for pulverized paint-layers and VA 2 EGA for adhering the flaking parts of the paint-layer or gold. The concentration of the material must be chosen, depending on the character and degree of destruction.

Till now, the results of the treatment proved to be satisfactory: paint layers are firmly attached to the parchment; the colours have not changed in nuances and all miniatures keep their original lustreless appearance (Fig. 2, 3a and b).

Illustrations

(all the miniatures are considerably enlarged in the photos)

Fig. 1 a) The example of typical destructions in Byzantine miniature painting (fragment from Leningrad State Public Library, gr. 379);

b) Flaking of the paints from the parchment and the golden background (fragment from the Gospels and Apostle, XII - XIII centuries, Leningrad State Public Library, gr. 101, vol. II, f. 51).

Fig. 2 Detail from the XIII century miniature (Leningrad State Public Library, gr. 101, vol. I, f. 10 v°),

a) before treatment,

b) after treatment.

Fig. 3 St. John. The XII century miniature (Leningrad State Public Library, gr. 101, vol. II, f. 44).

The left part of a miniature is already treated by VA 2 EGA. No visible change in colour occurs, as seen in the photo.

LE PROBLEME DE LA CONSOLIDATION DES COUCHES PICTURALES DES ENLUMINURES QUELQUES ESSAIS

Agnes BALLESTREM
Eddy DE WITTE

Dans le cadre des travaux du C.R.C.D.G. sur la technologie et la conservation des enluminures, Mme Françoise Flieder, qui dirige cette institution, nous a demandé d'entreprendre quelques essais de consolidation des couches picturales des enluminures sur la base de nos expériences de consolidation de polychromies des sculptures.

Malgré que les problèmes semblent différents, certains d'entre eux demandent une même approche à leur solution. Lors de la consolidation des couches de polychromie, on rencontre également le problème des couleurs très sensibles aux modifications d'aspect provoquées par des produits de consolidation. On recherche donc, comme pour les enluminures, une solution qui permette de refixer les couches picturales sur leur support, de garantir à ce collage une élasticité qui lui permette de résister aux mouvements plus ou moins continuels d'un support sensible aux variations hygrométrique - et, dans le cas des enluminures, aux sollicitations mécaniques - sans modifier l'aspect de l'oeuvre ni mettre en danger sa conservation future.

Notre contribution a consisté en une enquête dans la littérature spécialisée et des essais de divers produits sur des échantillons préparés en atelier. Nous avons procédé comme suit :

A. Recherche et dépouillement des travaux publiés sur la consolidation des couches picturales des enluminures (voir Annexe I).

Le dépouillement de cette littérature a montré qu'il semble y avoir deux tendances dans le choix d'un fixatif :

1) le fixatif réversible - donc une matière non apparentée, dans son comportement et sa solubilité, aux matériaux picturaux ni au support : résines synthétiques, matières cireuses ;
2) le fixatif irréversible - mais d'une matière semblable ou identique dans son comportement à celui des matériaux originaux : colle de parchemin, gélatine, colles cellulosiques.

Les produits signalés dans ces publications sont les suivants
- acétate de polyvinyle (0,5 % dans le toluol : acétone, 2 : 1)
- alcool polyvinylique (5 %)
- cellulose benzylique (1 % dans le benzol)
- cellulose méthylique (2,5 % dans l'eau)
- cire d'abeille (dans l'essence de térébenthine)
- cire d'abeille - dammar (5 : 4)
- cire microcristalline (point de fusion 105-107 °C)
- colle de parchemin
- gélatine

- polyamide à base de méthyldiamine (2 - 10 %)
- polyméthylméthacrylate (0,7 % dans le toluol ; 0,8 % dans le toluol + acétone, 2 : 1 ; 1 % dans le toluol ; 5 %)

B. Application des produits mentionnés dans les publications et d'autres que nous connaissions.

1) sur une couche de kaolin liée à la colle animale, très sensible aux modifications d'aspect
   - les observations (à l'oeil nu) ont porté sur la brillance et les changements de couleur

2) sur parchemin vierge
   - les observations (à l'oeil nu) ont également porté sur la brillance et les changements de couleur

3) sur une couche de kaolin en poudre, en gouttes de quantité égale
   - les observations (à l'oeil nu et au toucher) ont porté sur les qualités de pénétration et le pouvoir de cohésion des solution

4) sur couleurs liées à la gomme arabique à 10 % et d'autres à la gélatine à 10 %
   - les observations (à l'oeil nu) ont porté sur les changements de couleur.

5) sur couleurs peu liées (gomme arabique 5 %)
   - les observations (à l'oeil nu et au pliage répété du parchemin ont porté sur les changements de couleur et le pouvoir fixatif

Les adhésifs suivants ont été choisis pour ces essais :
- acétale de polyvinyle (Rhovinal) à 5 % dans l'alcool
- acétate de polyvinyle (fixatif Talens) dans l'alcool
- acétate de polyvinyle en émulsion (Ponal, Henkel) dilué dans l'Agepon, Agfa
- carboxyméthyle cellulose (CBR 4000) à 2,5 % dans l'eau
- cire d'abeille blanchie + térébenthine
- cire d'abeille - dammar (5 : 4)
- cire microcristalline (Cosmoloïd 80 H)
- colle de parchemin à 10 %
- gélatine à 1 et 10 % dans l'eau
- gomme arabique à 5 et 10 % dans l'eau
- hydroxyethyle cellulose (Vatrosol, Hercules) à 2,5 % dans l'eau
- méthylméthacrylate (Bedacryl 122 X) à 1, 5 et 10 % dans le xylol
- méthyle cellulose (Tylose MH 200 XP) à 0,5 % dans l'eau
- Méthyle cellulose (Tylose, MH 300 P) à 0,5, 1 et 2,5 % dans l'eau
- nylon soluble (Calaton, ICI) à 5 et 10 % dans l'alcool
- résine acrylique (Paraloïd B 72) à 2,5 et 10 % dans le toluol
- résine acrylique en émulsion (Rowney)

Après les trois premiers tests, les produits provoquant une trop grande modification d'aspect furent éliminés.

En ce qui concerne les produits en solution aqueuse, nous avons concentré notre attention sur les colles cellulosiques, encouragés par les résultats très favorables des tests de vieillissement faits sur ces colles par le C.R.C.D.G. (Flieder, F., communication verbale, janvier 1972).

Pour le détail des observations, voir Annexe II.

Les derniers essais (5) ont montré que le Bedacryl 122 X méthacrylate) à 1 % et le Paraloïd B 72 (résine acrylique) à 2,5 % modifiaient le moins l'aspect des couches imprégnées. Mais leur pouvoir adhésif était pratiquement nul. Celui des trois colles cellulosiques à 2,5 % semblait au contraire excellent, mais il y avait un certain assombrissement des couleurs. Comme il nous semblait que le changement de couleur était surtout dû à une trop forte imprégnation de la couche picturale à liant aqueux par la solution d'adhésif également aqueux, nous avons tenté d'imperméabiliser légèrement cette couche avant d'y introduire l'adhésif.

Un échantillon de couche picturale sur parchemin fut d'abord imprégné par vaporisation (aérographe, cf. Wächter, 1968), de Paraloïd B 72 à 2,5 % dans du toluol. Après séchage complet, l'échantillon fut imprégné par vaporisation à deux reprises d'une solution aqueuse d'hydroxyéthyle cellulose à 1 %. Selon nos observations, l'adhérence était bonne, le changement de couleur très faible, mais la surface restait légèrement poudreuse. Pour un autre échantillon, nous avons augmenté la concentration de la solution cellulosique jusqu'à 1,7 % avec bon résultat.

L'échantillon ainsi traité fut remis au laboratoire de l'Institut et soumis à un certain nombre de tests (voir rapport de E. De Witte, Annexe III).

Conclusions

Dès le début de nos travaux, nous n'avons guère espéré trouver une solution définitive au problème qui nous avait été posé. Nous étions trop conscientes de notre manque de connaissances et d'expérience dans le domaine des enluminures, tant du point de la technologie que de la manipulation et des multiples problèmes de conservation de ces oeuvres. Nous avons publié notre attitude dans l'approche d'un problème particulier en conservation de sculptures (Ballestrem, A., Cleaning of Polychrome Sculpture, dans Conservation of Stone and Wooden Objects, Preprints IIIC New York Conference 1970, p. 69è73) et nous respectons donc la même attitude dans l'approche de tout autre problème de conservation.

A la fin des essais entrepris, nous constatons que nous avons beaucoup appris, tant sur le comportement des matériaux que sur les difficultés qu'il peut susciter. Il n'est pas nécessaire d'énumérer en détail nos constatations sur ces points. Le restaurateur spécialisé ~~les connaît~~ dans la conservation des documents graphiques et enluminés les connaît, et le restaurateur non encore spécialisé dans ces traitements et confronté avec des problèmes de consolidation de couches picturales d'enluminures sera obligé, à notre avis d'entreprendre un programme d'information et d'essais bien plus important que le nôtre pour acquérir les connaissances requises pour traiter les oeuvres en danger.

Il nous semble cependant utile d'insister sur la nécessité d'approfondir et d'élargir nos essais, et notamment :

a) de vérifier dans quelle mesure l'application locale d'une résine synthétique (± 2,5 %) ou d'un adhésif cireux influence le comportement du support (parchemin, papier, textile), par exemple vis-à-vis des variations hygrométriques;

b) de vérifier la méthode combinée "résine synthétique - colle cellulosique" - en l'occurrence le Paraloïd B 72 et l'hydroxythyl cellulose; en essayer d'autres variantes.

Enluminures - consolidation de la couche picturale.

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sous la direction de W.S. LUBLINSKI, Moscou - Leningrad, 1963, 96 ill.

- sur parchemin ; feuilles de 28 x 20,5 cm ;

lors d'un traitement en 1938 fixage avec une solution de 1% de cellulose benzylique dans du benzol (assez bon comportement depuis) ; employé lors du traitement public solutions de 2-10% de polyamide ~~de methylol~~ à base de methylolamine ; application selon nécessité — 3x.

BHOWMIK, S.K., A non-aqueous method for the restoration of indian miniature paintings, in Studies in Conservation, vol. XII n° 3, 1967, p. 116 à 119.

- sur papier ; consolidation de la c.p. avec une solution d'acétate de polyvinyl à 0,5% dans du toluol et de l'acétone (2:1) ; couche protectrice après traitement avec une solution de polymethyl méthacrylate à 0,7% dans du toluol.

BHOWMIK, S.K., Conservation of indian miniature paintings in the Baroda Museum, Museum Bulletin, vol. XXI, 1969, p. 33-45 ill.

- sur papier ; consolidation de la c.p. avec une solution de polyméthyl méthacrylate à 0,8 % dans du toluène et de l'acétone (2:1) ; couches "préservatrice" avec une solution de polymeth. methacrylate à 0,7% dans du toluol.

ECKHARDT, H., Restaurierung einer Handschrift (Codex) aus dem Halberstädter Dom in, Neuewmuseumskunde, X, 1, 1967, p. 45-60.

- sur parchemin, milieu XIVe s., école italienne; fixage avec colle de parchemin.

GAIROLA, T.R., Preservation of a textile and a miniature painting, Ancient India, XIII, 1956, p. 143-145.

- sur papier ; fixatif : solution de methyl-methacrylate à 1%, appliquée à deux reprises.

GAIROLA? T.R. Preservation of a miniature and a wall-painting, in Ancient India XVI, 1960, p. 85-88.

- sur papier, XVIIIe s., école de Deccani (Hyderabad) ; fixative : solution de methyl methacrylate à 5%.

HORTAN, H., LESKY, E., WACHTER, O., Anatomia Universae Pauli Mascagnidis. Restaurierte von der Meisterschule für Konservierung und [illegible] [illegible] Institutes [illegible] Wien [illegible] Bp., [illegible]

- sur papier, XVIIIe s. ; fixage des couleurs en vue de lavage des feuilles dans des solutions aqueuses : solution très légère de gelatine + quelques gouttes de formaline vaporisée à l'aide d'un aérographe ; fixation définitive avec de la cellulose méthylique (Tylose SL 400, Kalle & Co., Wiesbaden).

KUHN, H. Examen et conservation de la charte de 972 relative au mariage de la princesse Théophanie (archives d'état de Basse-Saxe, Wolfenbüttel) Réunion Mixte du Comité d' l'ICOM pour les Laboratoires de Musées ... Bruxelles, 1967, 4p.

- sur parchemin, école byzantine, 144,5 x 39,5cm ; fixage avec de la cire d'abeille dissous dans de l'essence de térébenthine fraichement rectifiée et appliquée sous faible chaleur.

MARCONI, B., Some tests on the use of Wax for fixing flaking paint on illuminated Parchement, in Studies in Conservation, vol. VII, n° 1, 1962, p.17-21.

M. se déclare contre les adhésifs en solutions aqueuses, à cause de la sensibilité du parchemin et de la c.p. à l'eau.

Essaies avec cire micro-crystaline (point de fusion 105-107°C) et mélange de cire d'abeilles et dammar (5:4) ; appliquer avec légère chaleur pour éviter une imprégnation profonde : bons résultats en deux cas, changement de couleurs en un cas.

Essaiavec solution d'alcool polyvinylique à 5% : également changement de couleur.

MARCONI, B., Aesthetic problems in Conservation of art objects on paper and parchment, ICOM Comitee for Conservation, Amsterdam, 1969, 7p.

Se déclare pour l'emploi de la cire. L'intensification des couleurs doit être acceptée comme restitution hypothétique de leur valeur optique presque originale.

PORCHER, J. Rapport sur le traitement des manuscrits à peinures, ICOM, réunion de Barcelone, 1961 (octobre) 3p.

Rapport sur le système du"transfert" et le collage de la c.p. par "recouvrement". Opte d'après les résultats d'essaies pour l'acétate de polyvinyl.

WACHTER, O., Uber Instandsetzung von Pergament, Miniatur und Schrift, in, Leder und Graphikpflege, Stuttgart, 70, 1957, p.397. Par exemple.

Wächter, O., The Restoration of the "Vienna Dioscorides", Studies in Conservation, 7, 1 (1962), 22-25.

WACHTER, D., Die Restaurierung des Wiener Dioskurides als technologisches Problem, in Osterreichische Zeitschrift für Kunst und Denkmalpl. XVI, 1962, 4, PP. 150-54.

- sur parchemin, ~ 5/2, école byzantine ; 392 images en ~~pleine~~ pleine page ; fixative pour la c.p. : colle de parchemin.

WACHEER, O., Die Restaurierung einer armenischen Evangelienhandschrift (cod. 242) aus der Bibliothek der Mechitaristen-Congregation in Wi in Osterreichische Zeitschrift für Kunst und Denkmalpflege, XXIII, 1968, P. 43-47.?

- sur papier, XIVe s., 242 feuilles presque toutes enluminées, 24,5 x 19,3 cm, couleurs sombres et mats ; une première fixation avec une solution très légère de colle de parchemin vaporisée à distance avec l'aide d'un aérographe (1 att) après prémouillage à l'alcool ; puis fixage plus fort avec une solution de cellulose methylique à 2,5% dans de l'eau (Tylose SL 400 de Kalle & Co, Wiesbaden).

	sur kaolin + colle anim.		sur parchemin		sur kaolin en poudre (gouttes)		sur couleurs liées gomme arab. 10 %	sur couleurs liées gélatine 10 %	sur coul peu li	
	bril-lance	chang. coul.	bril-lance	chang. coul.	pénétr.	cohés.	chang. coul.	chang. coul.	chang. coul.	p
Gélatine 10 %	+	+++	+++	+++	+	++				
Gomme arabique 5 %	sans	sans	++	++	+++	++				
Gomme arabique 10 %	++	+++	+++	+++	+++	++				
Hydroxythyl cell. (Vatrosol, Hercules) 2,5 %	sans	sans	±	sans	+	++			++	+
Méthylméthacrylage (Bedacryl 122 X) 1%	sans	sans	sans	sans	+	0	sans	sans	sans	
idem 5 %	sans	sans	sans	±	+	0	sans	sans	+	
idem 10 %	sans	+	++	+	++	+	sans	sans	++	
Méthyl cellulose (Tylose MH 200 XP) 0, 5 %	sans	sans	+	sans	++	++			++	+
Méthyl cellulose (Tylose MH 300 P) 0, 5 %	sans	sans	sans	sans	++	+	+	+		
idem 1 %	sans	sans	sans	sans	++	+	+	+		

9/8/1972 E. De Witte

Tests de laboratoire sur des échantillons traités

Nous avons contrôlé l'efficacité de la consolidation des couches picturales. Les tests ont porté sur les propriétés suivantes :

1. Adhérence et cohésion.
2. Influence des variations hygrométriques.
3. Résistance aux vapeurs d'acide acétique.
4. Résistance aux rayons ultra-violets.
5. Compatibilité Paraloïd-Hydroxyéthylcellulose (HEC).

1. Adhérence et cohésion

Il existe deux formes de destruction de la couche picturale l'écaillage, lorsqu'il y a perte d'adhérence, et la pulvérulence, provoquée par un manque de cohésion. Il fallait donc contrôler ces deux qualités en même temps, ce qui fut fait à l'aide de mandrins cylindriques. En roulant le parchemin avec la couche picturale à l'extérieur, on n'observe ni écaillage, ni pulvérulence, même en utilisant le mandrin de 2 mm de diamètre. En roulant le parchemin avec la couche picturale à l'intérieur, on remarque quelques légèr craquelures avec la mandrin de 5 mm ; avec celui de 2 mm, on obser des écaillages assez importants.

2. Influence des variations hygrométriques

Un échantillon, gardé pendant plusieurs jours dans l'atmosphère du laboratoire (20° C, 65% H.R.), a été exposé alternativeme à l'humidité et à la sécheresse selon le cycle suivant :

19 h. à H.R. 100 %
2 h. à H.R. 5 %
2 h. à H.R. 100 %
2 h. à H.R. 5 %

On n'a pas observé de changement de couleur. Le parchemin ayant tendance à se rouler et à se ramollir à l'humidité, de nombreuses écailles ont apparu, avec perte d'adhérence. La cohésic par contre, était satisfaisante.

3. Résistance à la vapeur d'acide acétique

L'échantillon a été exposé pendant 30 h. à une atmosphère de 10 % d'acide acétique dans l'eau. Après ce temps, on a constaté une légère décoloration du pigment et quelques petites écailles. Comme on sait déjà que cet écaillage est dû à l'influence de l'humidité, on peut conclure que l'acide acétique n'a pas d'influence.

4. Résistance aux rayons ultra-violets

Un échantillon a été exposé à une lampe UV Philips TL 40 W/8 à une distance de 1 cm pendant 168 h. A l'oeil nu, on ne voyait aucun changement. En fluorescence UV, le parchemin exposé avait un aspect plus foncé que le parchemin non exposé, mais on n'apercevait aucune différence entre les endroits traités et les endroits non traités. Ceci prouve que le parchemin sera plus vite altéré par les rayons UV que les résines employées.

5. Compatibilité Paraloïd-Hydroxyéthylcellulose (HEC)

Puisque le Paraloïd et le HEC sont deux résines de nature tout à fait différente, il fallait contrôler s'ils sont compatibles. Ils ne le sont pas lorsqu'ils sont appliqués en films ou en gouttes assez grosses. Ils n'ont qu'une adhérence très faible l'un avec l'autre. Comme le rôle du Paraloïd est d'imperméabiliser le parchemin, il faut bien veiller à ce que la solution soit pulvérisée en microgoutelettes.

Conclusions

On peut conclure de ces tests que la combinaison Paraloïd-Hydroxyéthylcellulose donne à la couche picturale une assez bonne cohésion et une adhérence suffisante. La stabilité aux vapeurs d'acide acétique et aux rayons UV est bonne, mais des variations hygrométriques sont à éviter.

Puisque le Paraloïd et l'Hydroxyéthylcellulose ne sont pas compatibles, il serait intéressant d'examiner d'autres résines cellulosiques qui joueraient le rôle d'imperméabilisant.

	sur kaolin + colle anim.		sur parchemin		sur kaolin en poudre (gouttes)		sur couleurs liées gomme arab. 10 %	sur couleurs liées gélatine 10 %	sur coul. peu liées
	bril-lance	chang. coul.	bril-lance	chang. coul.	pénétr.	cohés.	chang. coul.	chang. coul.	chang. coul.
idem 2, 5 %									++
Nylon soluble (Calaton ICI) 5 %	+	sans	+	+	+	+			
idem 10 %	+	++	++	++	0	0			
Résine acrylique (Paraloïd B 72) 2, 5 %	sans	+	++	++	+	0	sans	sans	0
idem 10 %	sans	sans	+	sans	+	+			
Résine acrylique en émulsion (Rowney)	+++	sans	+++	+	0	0			

Produit	sur kaolin + colle anim.		sur parchemin		sur kaolin en poudre (gouttes)		sur couleurs liées gomme arab. 10 %	sur couleurs liées gélatine 10%	sur c[illegible] peu [illegible]
	bril-lance	chang. coul.	bril-lance	chang. coul.	pénétr.	cohés.	chang. coul.	chang. coul.	chang. coul.
Acétale de polyv. (Rhovinal) 5%	sans	sans	+	±	+	++			
Acétate de polyv. (fixatif Talens)	sans	sans	sans	sans	++	+	sans	sans	
Acétate de polyv. (émulsion Ponal)	sans	±	+	+	0	0	+	+	
Carboxyméthyl cellulose (CBR 4000) 2,5 %	sans	sans	sans	±	+	±	++	sans	
Cire d'abeille blanchie (excédent éliminé)	sans	±	sans	sans					+++
Cire d'abeille - dammar (5/4) (excédent éliminé)	sans	++	sans	±					+++
Cire microstalline (Cosmolod 80 H) (exédent éliminé)	sans	++	sans	sans					
Colle de parchemin 10 %	sans	+	++	++	++	++			
Gélatine 1 %	sans	sans	sans	+	+++	+	+	+	

ANNEXE

CONSIDERATIONS DE BASE SUR L'OPPORTUNITE DES MESURES DE CONSERVATION ET DE RESTAURATION DE CERTAINES FORMES D'ART ACTUEL.

PAOLO CADORIN

Notre groupe de travail ne semble pas directement concerné par les problèmes de l'art actuel, où il est souvent question de tout à l'exception de "peinture". Nous voulons cependant poser une question, même si elle dépasse notre sujet, parcequ'elle est urgente, et demande une réponse ou une prise de position dans les plus brefs délais.

Le développement de l'art depuis la fin du XIXe siècle est fait d'une suite de refus qui ont permis la conquête d'un monde radicalement nouveau dans l'expression artistique; l'aboutissement de ces refus se trouve aujourd'hui dans la tentative d'assumer les affirmations les plus contradictoires.

La contestation d'un ordre établi, d'une académie, est un phénomène qui commence peu après la création de ces Académies après la Révolution Française, puis s'affirme dans la deuxième moitié du XIXe siècle lorsque les pleinairistes abandonnent l'atelier pour observer de plus près les effets de la lumière du jour.

Avec le goût de la réalité, de la vérité, toute la hiérarchie des genres (le plus grand, le plus respecté était le "genre Historique"), est bouleversée. Plus de "célébrations" d'un évènement de l'histoire des hommes, plus de "grands formats" montrant à quel point on prend au sérieux ces évènements, mais la recherche du contact avec la nature, au mépris de tout ce qu'enseignait la tradition.

Les impressionnistes qui peignent et finissent leurs tableaux dehors, éliminent peu à peu le noir, les terres, les demi-tons, le clair-obscur, la plasticité, le "naturel" de la peinture tonale, au profit de la luminosité, de l'honnêteté de peindre un effet perçu par l'oeil (la vision colorée n'étant pas une réalité, mais une traduction au niveau de la rétine d'ondes lumineuses).

Gaugin, puis les Nabis et les Fauves éliminent l'illusion de la troisième dimension.

Cézanne puis surtout les cubistes Braque et Picasso ne se plient plus à la loi du point de fuite unique. Ils multiplient les points de fuite afin de rythmer le volume d'un objet sans tomber dans le leurre de l'illusion.

Les peintres cubistes limitent la gamme des couleurs jusqu'à n'en utiliser plus qu'une seule: l'ocre.

Le détail des formes du sujet est écarté (impressionnistes, fauves, cubistes). Bientôt la forme devient indépendante du sujet (cubisme, Kandinsky, et tous les peintres dits abstraits).

à la création d'une oeuvre d'art (Mondrian et Bauhaus).

Ces négations de la vision et de l'esthétique traditionnelles sont doublées de négations de la technique traditionnelle. Des matériaux non-orthodoxes sont utilisés dans la peinture: depuis le plâtre dans les maisons d'Utrillo jusqu'aux objets de la vie courante intégrés aujourd'hui dans les compositions de Rauschenberg, en passant par les papiers, liège, bois, verre ... (Voir la contribution de Madame R.Hammacher: "Les matières dans les oeuvres d'art du XXe siècle).

Un artiste a rompu plus radicalement encore avec la technique traditionnelle: Yves Klein, lorsqu'il créa la boîte de plexiglas remplie de poudre bleue (pigments de bleu outremer, sans liant). Déjà, ce pigment sans liant semblait un aboutissement dans ce mouvement de contestation: l'éphémère était incarné.

Vinrent alors les dernières oeuvres de Klein où l'artiste créait des sculptures avec les flammes du gaz, jetait de la poudre d'or dans l'espace: l'air devenait un liant passager. Cette forme d'expression tient cependant plutôt du spectacle, de l'art cynétique que de l'art plastique.

C'est alors que certains artistes ont intégré l'éphémère, le périssable dans leur oeuvre, comme un élément constitutif de celle-ci. L'oeuvre est justifiée par des éléments qui la détruisent. Le temps est entré dans l'art comme une dimension supplémentaire.

Mais plus souvent, l'artiste, sans rechercher la destruction autonome de son oeuvre, ne se préoccuppe simplement pas de sa durabilité (enthousiasme pour les matériaux nouveaux qu'il découvre ou indifférence à l'égard d'une postérité).

Les musées se trouvent ainsi devant un triple problème:

1) Technique: comment restaurer des oeuvres conçues dans des matériaux que nous connaissons à peine (Voir la contribution de W.Hahn sur les Nouveaux Problèmes de Conservation posés par les Techniques de l'Art Moderne).

2) Moral: Faut-il restaurer et dans quelle mesure ? Avons nous le droit d'intervenir dans ce processus normal et plus ou moins voulu par l'artiste au départ. Le problème se complique encore lorsqu'un artiste qui a créé une oeuvre instable. déclare après coup que l'on pourrait arrêter le processus de dégradation. Cette deuxième attitude est sincère, même si elle est empreinte de vanité. (Ainsi, Beuys a proposé de remplacer la margarine par de la cire dans une de ses oeuvres. On revient de la vie à une simulation de vie.)

3) Juridique: Dès qu'une oeuvre entre dans un musée elle devient un bien public. Quelles sont les responsabilités du conservateur et du restaurateur ?

Je vous pose le problème en vue d'une discussion, et d'une prise de position.

Un élément de la discussion serait de voir quelle importance nous devons donner aux déclarations des artistes sur leurs oeuvres, quelques années après la création de

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REUNION DU COMITE DE L'ICOM POUR LA CONSERVATION

Madrid , 2 - 7 octobre 1972

Etude du comportement du papier désacidifié par différents procédés

par

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Le but de notre travail est d'étudier expérimentalement un certain nombre de techniques de désacidification des papiers actuellement utilisées dans les laboratoires mondiaux, de manière à sélectionner celles qui, tout en étant efficaces, sont inoffensives vis-à-vis du papier. Nous décrirons dans cette communication les méthodes opératoires des différentes techniques passées en revue, avec les éventuelles modifications que nous leur avons apportées et les résultats obtenus sur des papiers de deux qualités différentes.

Afin d'examiner le oomportement de ces papiers traités, nous avons étudié leurs propriétés mécaniques, chimiques et optiques avant et après le traitement. Par ailleurs, souhaitant savoir si la désacidification serait encore valable dans de nombreuses années, nous avons examiné à nouveau la résistance des papiers après un vieillissement artificiel à la chaleur sèche.

Il est bien évident que nous ne pouvons pas retenir une seule technique car les problèmes posés par la désacidification peuvent revêtir différents aspects selon qu'il s'agisse d'un livre relié ou de feuilles volantes, et selon la qualité de l'encre utilisée. Notre désir est donc de définir pour chacun des cas la meilleure méthode.

CHOIX DES TESTS DE CONTROLE DE LA DEGRADATION DU PAPIER

L'étude a été menée sur deux papiers différents :

- un Afnor VII/1 : 100 % pâte chimique blanchie ;
- un Afnor VII/4 : 50 % coton, 50 % pâte chimique blanchie.

La qualité d'un papier peut être estimée grâce à certains indices mécaniques, chimiques et optiques. En dehors de la mesure du pH, tous ces tests sont effectués selon les normes de l'Association française de normalisation.

Les examens physiques retenus sont :

- la résistance à la pliure (norme NF Q 03.001)
- la résistance à la déchirure (norme NF Q 03.011)
- la résistance à la traction (norme NF Q 03.004)
- la résistance à l'éclatement (norme NF Q 03.014)

Tous les essais sont réalisés sur les deux sens du papier.

Les examens chimiques reflètent l'état de la cellulose contenue dans le papier. Parmi eux, nous avons retenu :

- l'indice de cuivre (norme NF T 12.004) qui mesure l'oxydation de la cellulose*;

- le degré de polymérisation viscosimétrique moyen (norme NF T 12.005) ;

- la mesure du pH (norme T.A.P.P.I. T 435 m 52).

Les produits utilisés pour désacidifier les papiers étant des sels minéraux, la charge des papiers traités augmentera. On estimera cette augmentation par la mesure du taux de cendres réalisée selon la norme T 12.002.

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* Il est à noter qu'à l'inverse de toutes les autres analyses, cet indice croît avec l'altération du papier.

Les examens optiques choisis sont :

- la mesure de la blancheur (norme NF Q 03.008)
- la mesure d'opacité de contraste du papier (norme NF Q 03.006).

Le vieillissement artificiel a été obtenu en laissant séjourner les papiers pendant 72 heures dans une étuve sèche, ventilée, maintenue à 105°.

DESCRIPTION DES DIFFERENTES TECHNIQUES DE DESACIDIFICATION

METHODES AQUEUSES

Toutes ces méthodes ont été mises au point au laboratoire du Pr BARROW (W.J. BARROW Research Laboratory Inc., Richmond, Virginia, U.S.A.) entre les années 1940 et 1959.

Méthode 1 :

Indications recueillies dans la littérature (1-5) :

On immerge les documents pendant 20 minutes dans une solution d'hydroxyde de calcium à 0,15 % et on les sèche. On les plonge alors 20 minutes dans une solution de bicarbonate de calcium à 0,15 % ; on sèche à nouveau. Dans le cas où, après traitement, il y aurait un dépôt blanchâtre à la surface du papier, on doit l'enlever à l'aide d'un pinceau.

Dans nos expériences : nous avons préparé la solution d'hydroxyde de calcium en dissolvant 13 g. d'oxyde de calcium dans un litre d'eau et en faisant barboter du CO_2 pendant 20 minutes au débit d'un litre par heure. La solution de bicarbonate de calcium a été obtenue d'une manière identique en partant de carbonate de calcium.

Méthode 2 :

Indications recueillies dans la littérature (2-5) :

On utilise une solution de bicarbonate de calcium à 0,2 %.

Dans nos expériences : on fait barboter pendant deux heures du CO_2 au débit d'un litre par heure dans une solution aqueuse de carbonate de calcium à 0,2 % sous agitation. La solution est décantée et les feuilles sont immergées pendant 20 minutes, puis séchées.

Méthode 3 :

Indications recueillies dans la littérature (3-4) :

On emploie une solution de bicarbonate de magnésium obtenue à partir d'une solution de carbonate de magnésium de 1 à 2,5 % dans laquelle on fait barboter du CO_2 pendant 2 heures. Le traitement peut être appliqué soit par trempage, soit par pulvérisation.

Dans nos expériences : on utilise une solution de carbonate de magnésium à 10 g. par litre dans laquelle on fait barboter du CO_2 pendant deux heures au débit d'un litre par heure sous agitation. On décante.

- méthode 3a : les feuilles sont trempées 20 minutes dans cette solution et séchées.
- méthode 3b : on pulvérise la solution recto-verso sur les papiers.

METHODES NON AQUEUSES

Méthode 4 (6) :

Elle a été mise au point par M. BAYNES-COPE (Research Laboratory, British Museum, London) qui utilise une solution d'hydroxyde de baryum de 0,2 à 10 % dans du méthanol.

Dans nos expériences : nous avons fait une solution à 1 % d'hydroxyde de baryum à partir de 19 g. de baryte octa-hydratée dissous dans un litre de méthanol.

- méthode 4a : les feuilles sont trempées 20 minutes dans la solution.
- méthode 4b : on pulvérise cette solution recto-verso sur les papiers.

Méthode 5 :

Nous avons utilisé un produit commercial, le Regnal 7P* vendu par la "World Patent Corporation". Les papiers sont pulvérisés recto-verso.

Méthode 6 :

Nous avons expérimenté un produit vendu par M. SMITH** sous forme de bombe (Richard Daniel SMITH, 2374 S. William, St Denver, Colo. 80210). Les feuilles ont été pulvérisées recto-verso.

Méthode 7 (4) :

Nous avons employé une solution d'acétate de magnésium à 1 % dans du méthanol, que l'on a utilisée soit par trempage, soit par pulvérisation.

METHODES GAZEUSES

Méthode 8 :

On soumet les papiers à des vapeurs ammoniacales à la concentration de 300 ml par m3 pendant six heures dans une étuve maintenue entre 35 et 40°.

Méthode 9 :

Cette technique a été mise au point par M. LANGWELL (9) et décrite par M. CARTHY (7). Celui-ci intercale dans les livres des papiers imprégnés d'une solution de carbonate de

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* La composition exacte de ce produit nous a été communiquée confidentiellement par cette firme.

** La composition du produit ne nous a pas été communiquée.

cyclohexylamine, produit très toxique qui stagne à l'intérieur des liasses de papier et qui, de ce fait, risque d'incommoder dangereusement les utilisateurs. Par ailleurs, selon les travaux de M. DUPUIS et de ses collaborateurs (8), il a été prouvé que l'encollage à la colophane est détruit et que le papier jaunit. Nous n'avons donc pas cru bon d'examiner l'efficacité de cette technique.

EXPRESSION DES RESULTATS

EFFICACITE DU TRAITEMENT

Comme nous venons de le voir, les méthodes aqueuses et non aqueuses s'effectuent soit par trempage, soit par pulvérisation.

L'immersion des documents présente de nombreux avantages :

- désacidification plus complète, car le produit pénètre mieux et les acides libres solubles* sont éliminés ;
- léger nettoyage des documents sans risque d'auréoles.

Cette technique n'est cependant applicable qu'aux feuilles volantes ou aux livres obligatoirement déreliés.

La pulvérisation est d'emploi plus aisé ; néanmoins nous faisons des restrictions quant à son utilisation sur des livres reliés : risques d'auréoles si le document n'est pas parfaitement propre ; difficultés de séchage, en particulier lorsque l'on utilise des solutions aqueuses ; enfin possibilité d'une déformation du papier.

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* Ils proviennent soit de l'oxydation de la cellulose ou de la lignine, soit de la décomposition des produits d'encollage.

La plupart des méthodes essayées ont considérablement augmenté le pH du papier qui s'échelonne entre 7 et 10. On peut cependant se demander si un pH de 10, comme celui obtenu dans la méthode 6, ne risque pas d'être trop alcalin.

Par contre, certains procédés ont été très peu efficaces :

méthode 2 : le pH du papier est passé de 5 à 6. Nous avons essayé de modifier la technique en utilisant soit une solution plus ou moins concentrée, soit en faisant barboter le CO_2 pendant des temps plus longs allant jusqu'à six heures. Les résultats ne se sont pas améliorés pour autant.

méthode 5 : le pH des papiers traités est passé de 5 à 6.

méthode 7 : qu'il s'agisse de pulvérisation ou de trempage, le pH du papier n'a jamais dépassé 6.

méthode 8 : le pH du papier traité est resté très acide. Pour l'Afnor VII/1, il est passé de 5 à 6 et pour l'Afnor VII/4 de 4,9 à 5,5.

COMPORTEMENT DU PAPIER

A l'exception de la méthode 5* (1), nous avons examiné la résistance des papiers traités par des méthodes augmentant substantiellement le pH.

D'après les tableaux et les courbes, nous pouvons conclure avec certitude qu'aucune des méthodes de désacidification étudiées n'a altéré la résistance du papier. Au contraire, dans la plupart des cas, on note une augmentation très importante de la résistance, particulièrement après vieillissement.

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* Le Régnal est un produit de renforcement contenant une substance alcaline vendu dans le commerce "prêt à l'emploi". Son utilisation en est très aisée et rapide, c'est pour cette raison que nous avons étudié ses effets.

E R R A T U M

Page 2, lire :

AFNOR VII/4 : 80 % coton, 20 % pâte chimique blanchie

au lieu de : 50 % coton, 50 % pâte chimique blanchie

En conclusion de ce travail, nous pouvons avancer les suggestions suivantes :

- D'une façon générale, avant tout traitement, il est indispensable de faire des essais de solubilité des encres dans l'eau et dans le méthanol pour sélectionner une technique. Dans le cas peu probable d'une encre soluble dans ces deux solvants, il ne faudrait pas désacidifier le document.

- S'il s'agit de désacidifier un volume que l'on ne peut absolument pas dérelier, on utilisera une pulvérisation. Dans le cas où l'eau ne risque pas de solubiliser les encres, on emploiera la méthode 3b, dans le cas contraire, la méthode 4b.

- S'il s'agit de désacidifier des feuillets volants, on utilisera de préférence une méthode par trempage ; la méthode 3a pour les documents ne craignant pas l'eau, la méthode 4a pour les autres.

La méthode 1 peut également être retenue, mais son mode opératoire est nettement plus long.

La méthode 6, a l'inconvénient d'alcaliniser le papier. Par ailleurs, c'est un produit inutilisable, parce que trop onéreux :, s'il s'agissait de désacidifier de très nombreux documents. En outre, nous ne pouvons préconiser un produit dont nous ne connaissons pas la composition.

Il est bien évident que ce travail n'est pas exhaustif, car nous n'avons examiné de près que les techniques qui nous ont paru être le plus couramment utilisées dans les différents ateliers. Il nous faudra donc, par la suite, poursuivre cette étude en fonction de toutes les nouvelles méthodes mises au point ; nous pensons en particulier expérimenter les techniques décrites par M. SMITH (10) au méthoxyde de magnésium ainsi que celles à base de borax et de bicarbonate de sodium, citées par Otto WACHTER (11).

Centre de Recherches sur la
Conservation des Documents Graphiques

Paris

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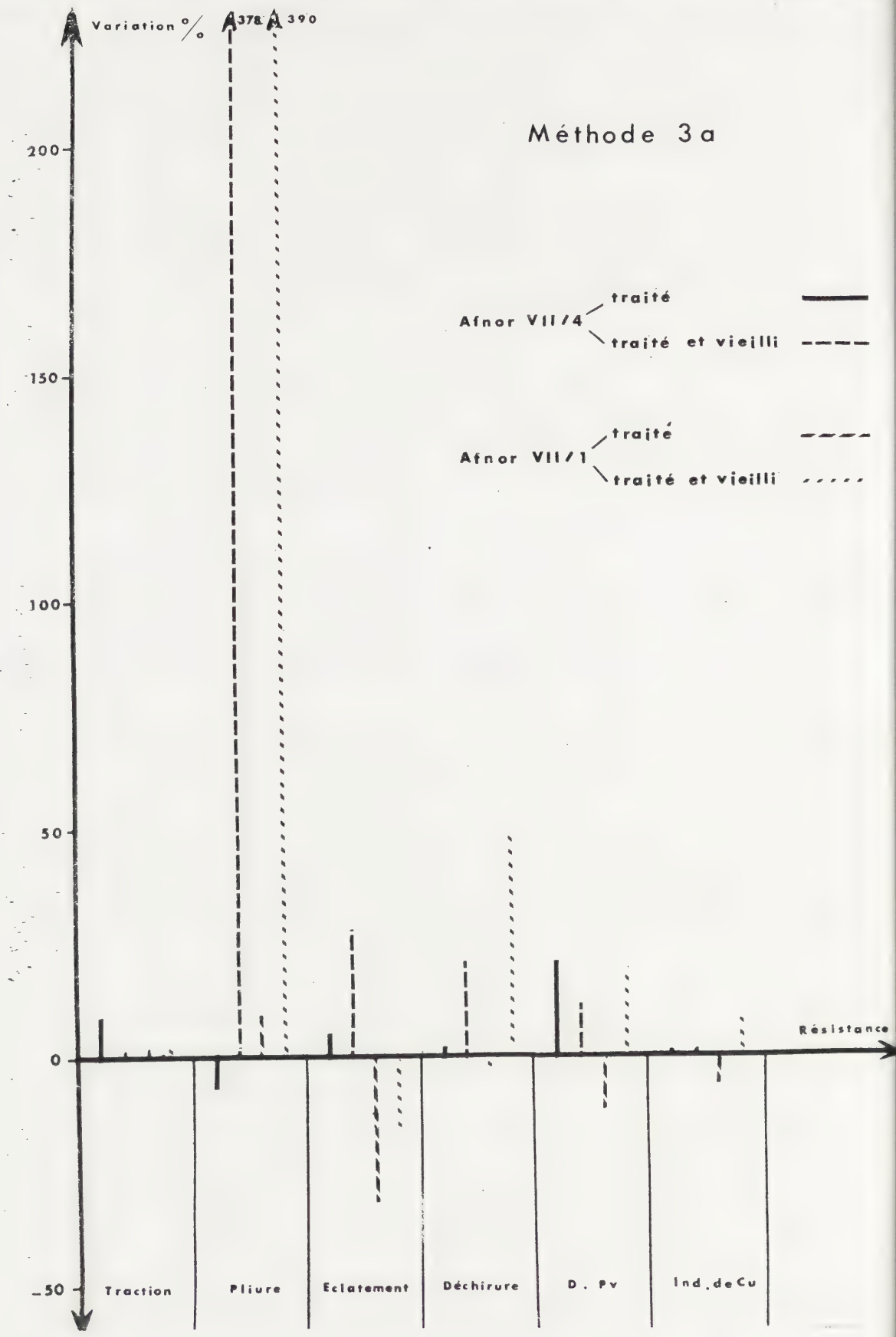
RESISTANCE MECANIQUE ET CHIMIQUE DES PAPIERS AFNOR VII_4 et VII_1

TRAITES PAR LA METHODE 1

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
NOR VII/4 témoin	2185	3280		* 39	103		17,3		80,1	71,6		77,5	93,5	409		1,32		4,9	1,30
NOR VII/4 traité	2230	3185	-1,5	34	71	- 22	17,2	+0,5	73,3	67,4	-7,2	76	95	446	+ 9	1,05	+ 20	9	2,55
NOR VII/4 vieilli	2076	3034		9	14		12,8		64	54,5		64	94,3	376		1,79		4.85	
NOR VII/4 traité vieilli	2175	3055	+2,7	21	45	+177	16	+ 25	71	59,2	+9,7	68	96	421	+12	1,55	+ 13	8.85	
NOR VII/1 témoin	3618	7310		** 66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,61
NOR VII/1 traité	3530	6880	-4,2	52	88	-14	27,8	-1,6	91,6	82,5	0	79	82,5	665	-7,3	1,67	+6,7	8,80	3,84
NOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
NOR VII/1 traité vieilli	3175	6370	+1,2	34	43	+379	25,9	+19	80	73,4	+33	73	84	579	+30	1,68	+27	8,7	

ST = sens travers SM = sens machine Var. = variation

* sous 500 g. ** sous 885 g.


Méthode 3a
Variation %
378
390
200
150
100
50
0
-50
Afnor VII/4
traité
traité et vieilli
Afnor VII/1
traité
traité et vieilli
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu

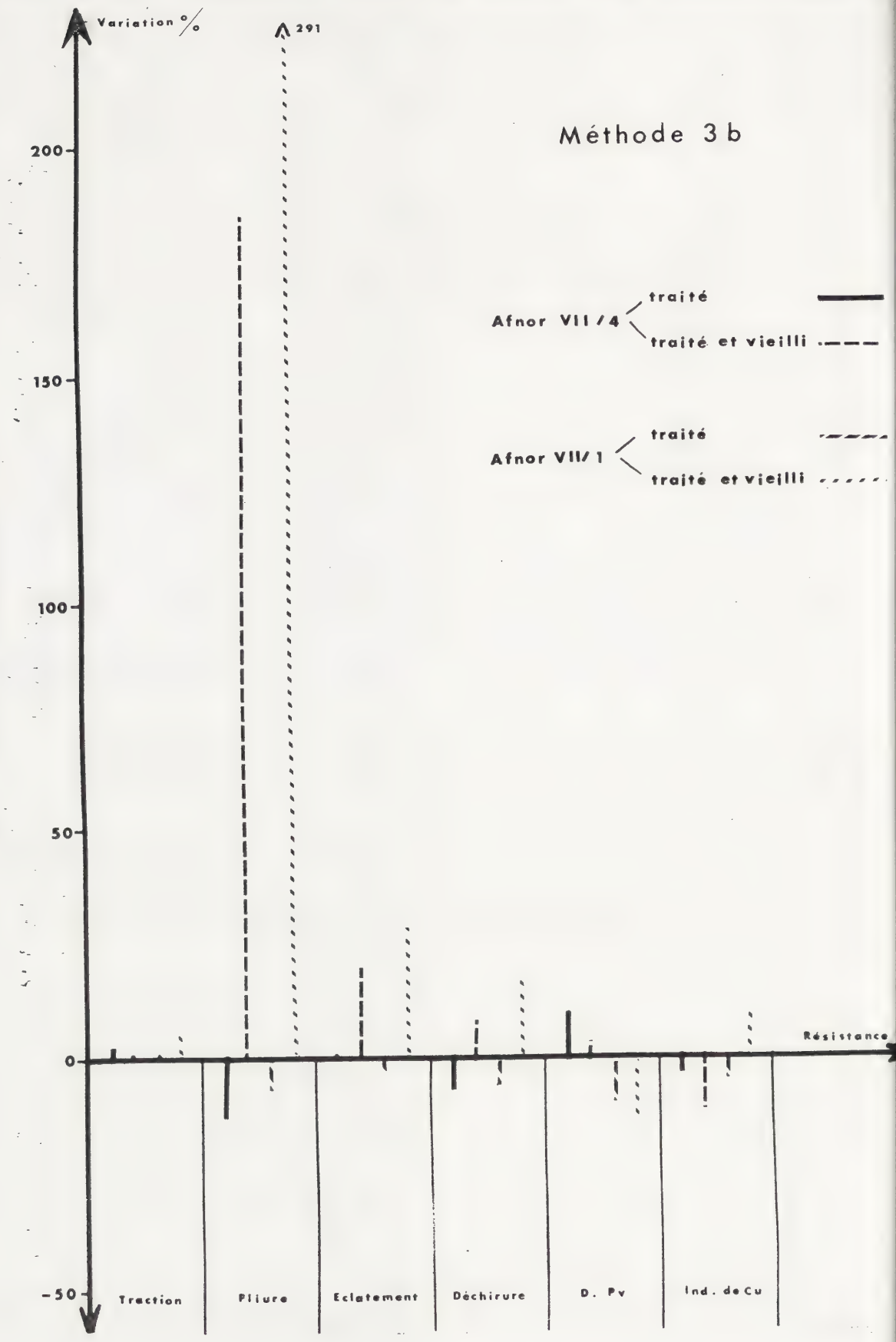
RESISTANCE MECANIQUE ET CHIMIQUE DES PAPIERS AFNOR VII/4 ET VII/1

TRAITES PAR LA METHODE 3a

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
NOR VII/4 témoin	2185	3280		* 39	103		17,3		80,1	71,6		77,5	93,5	409		1,32		4,9	1,30
NOR VII/4 traité	2510	3350	+8,4	48	90	-6,1	18,1	+4,6	75,6	73	+2	75	95	491	+20	1,32	0	7,95	1,52
NOR VII/4 vieilli	2076	3034		9	14		12,8		64	54,5		64	94,5	376		1,79		4,85	
NOR VII/4 traité vieilli	2110	3070	+1,4	34	81	+378	16,4	+28	84,6	75	+21	65	96,5	419	+11	1,79	0	7,8	
NOR VII/1 témoin	3618	7310		** 66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,61
NOR VII/1 traité	3820	7160	+1,7	79	95	+9,8	19,3	-31	90	80,8	-1,9	82	79,5	632	-12	1,91	-7	8,7	2,62
NOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
NOR VII/1 traité vieilli	3290	6410	+3,3	53	92	+390	18,1	-16	92,1	80	+50	68,5	78	532	+19	2,13	+7,4	8,65	

ST = sens travers SM = sens machine Var. = variation

* sous 500 g. ** sous 835 g.


Méthode 3 b
Variation %
291
200
150
100
50
0
-50
Afnor VII/4
traité
traité et vieilli
Afnor VII/1
traité
traité et vieilli
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu

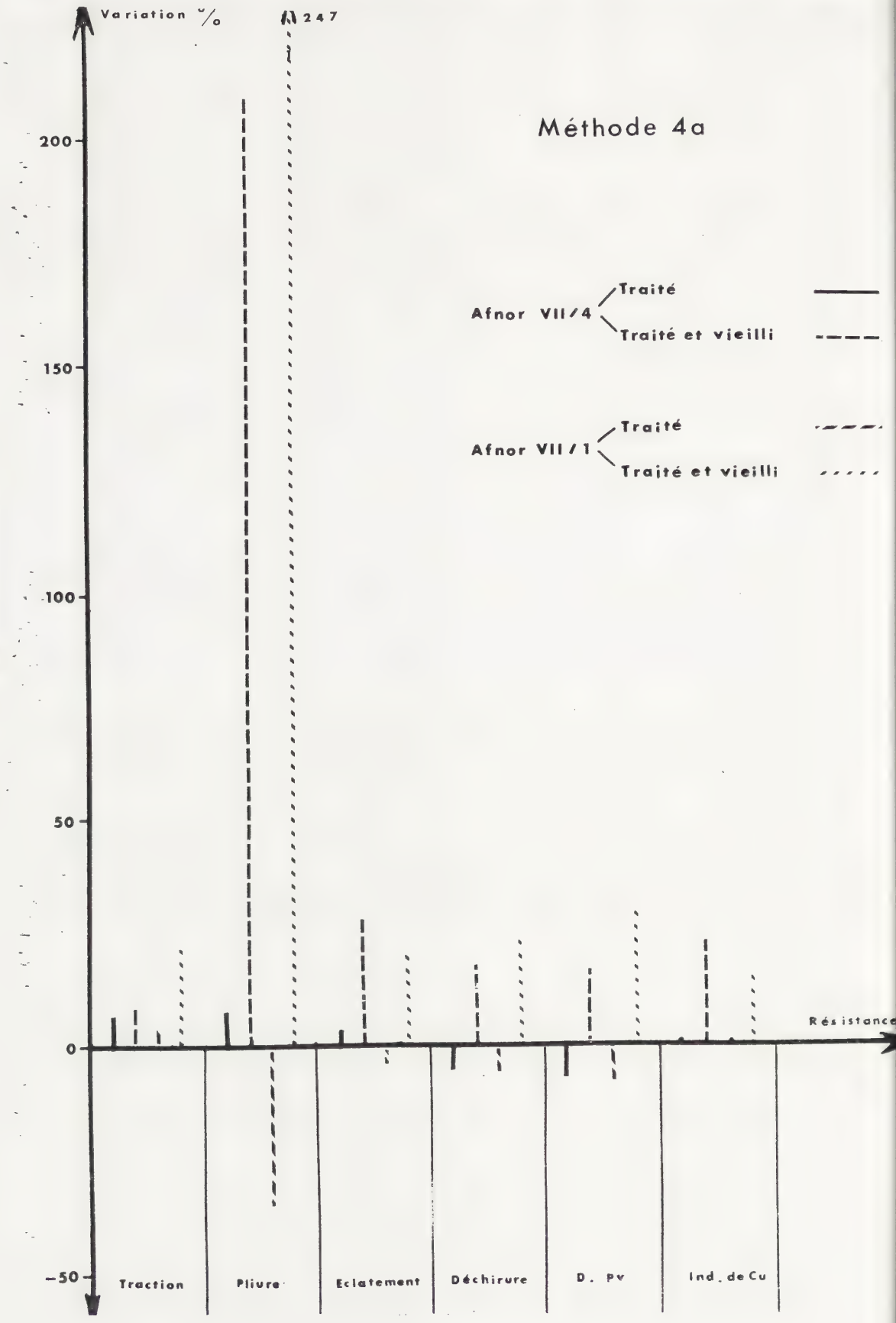
RESISTANCE MECANIQUE ET CHIMIQUE DES PAPIERS AFNOR VII/4 et /II/1

TRAITES PAR LA METHODE 3b

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
NOR VII/4 témoin	2185	3280		* 39	103		17,3		80,1	71,6		77,5	93,5	409		1,32		4,9	1,30
NOR VII/4 traité	2225	3390	+2,5	38	80	-12	17,1	-1,1	78,6	63,6	-6,4	75,5	94	449	+9,7	1,37	-3,7	7,30	1,36
NOR VII/4 vieilli	2076	3034		9	14		12,8		64	54,5		64	94,5	376		1,79		4,85	
NOR VII/4 traité vieilli	2110	2935	-1,6	25	41	+185	15,4	+20	74,6	62	+7,6	64,5	97	388	+3,1	1,99	-11	7,40	
NOR VII/1 témoin	3618	7310		** 66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,61
NOR VII/1 traité	3600	7065	-1,6	58	97	- 6	27,5	-2,1	85,4	78,7	-5,6	77,5	78	647	-9,8	1,87	-4,4	8,30	2,99
NOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
NOR VII/1 traité vieilli	3360	6540	+5,5	41	81	+291	27,8	+28	94,1	83,7	+54	67,5	82	388	-13	2,06	+10	8	

ST = sens travers SM = sens machine Var. = variation

* sous 500 g. ** sous 885 g.


Variation %
247
Méthode 4a
200
150
100
50
0
-50
Afnor VII/4
Traité
Traité et vieilli
Afnor VII/1
Traité
Traité et vieilli
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu

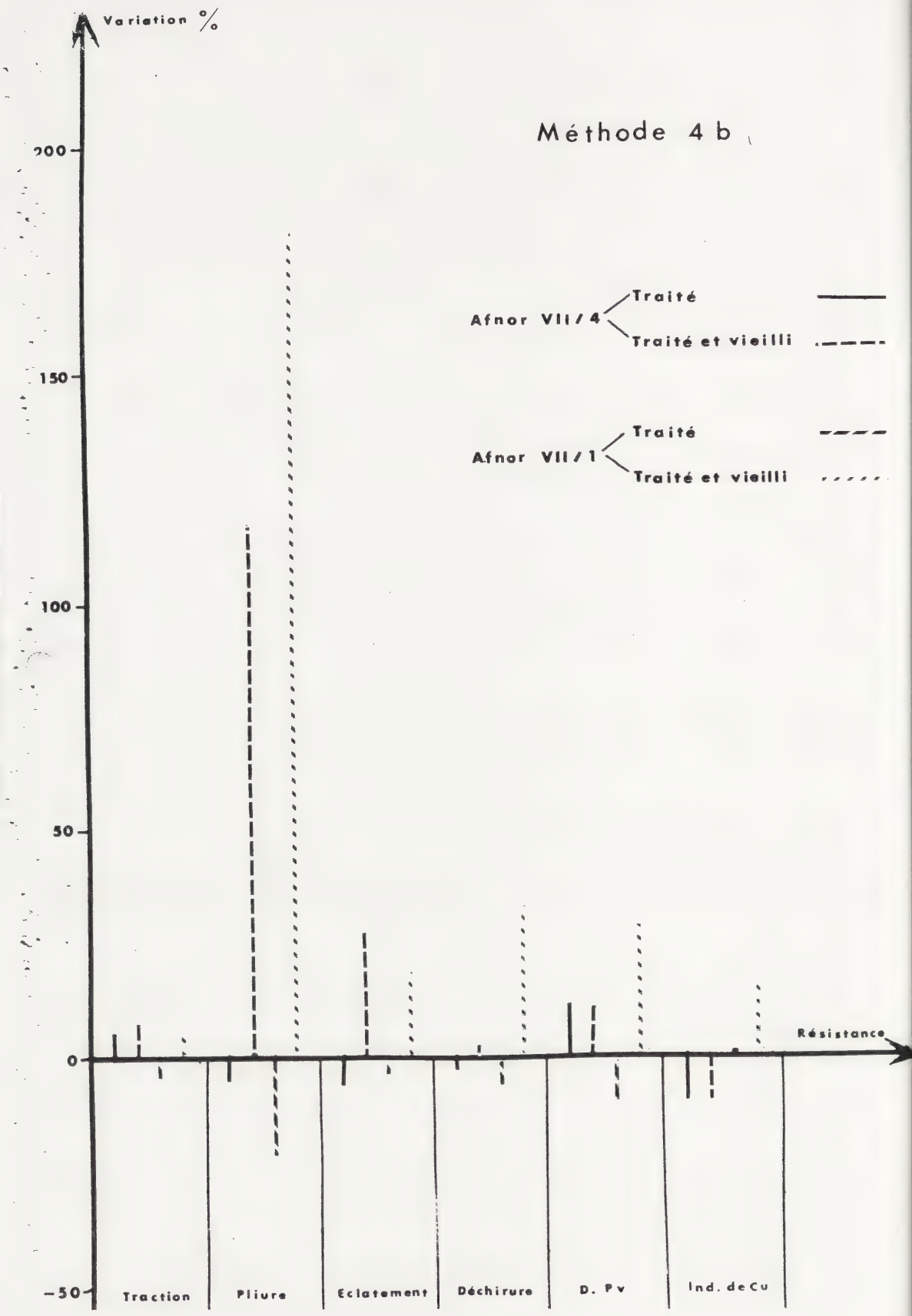
RESISTANCE MECANIQUE ET CHIMIQUE DES PAPIERS AFNOR VII/4 et VII/1

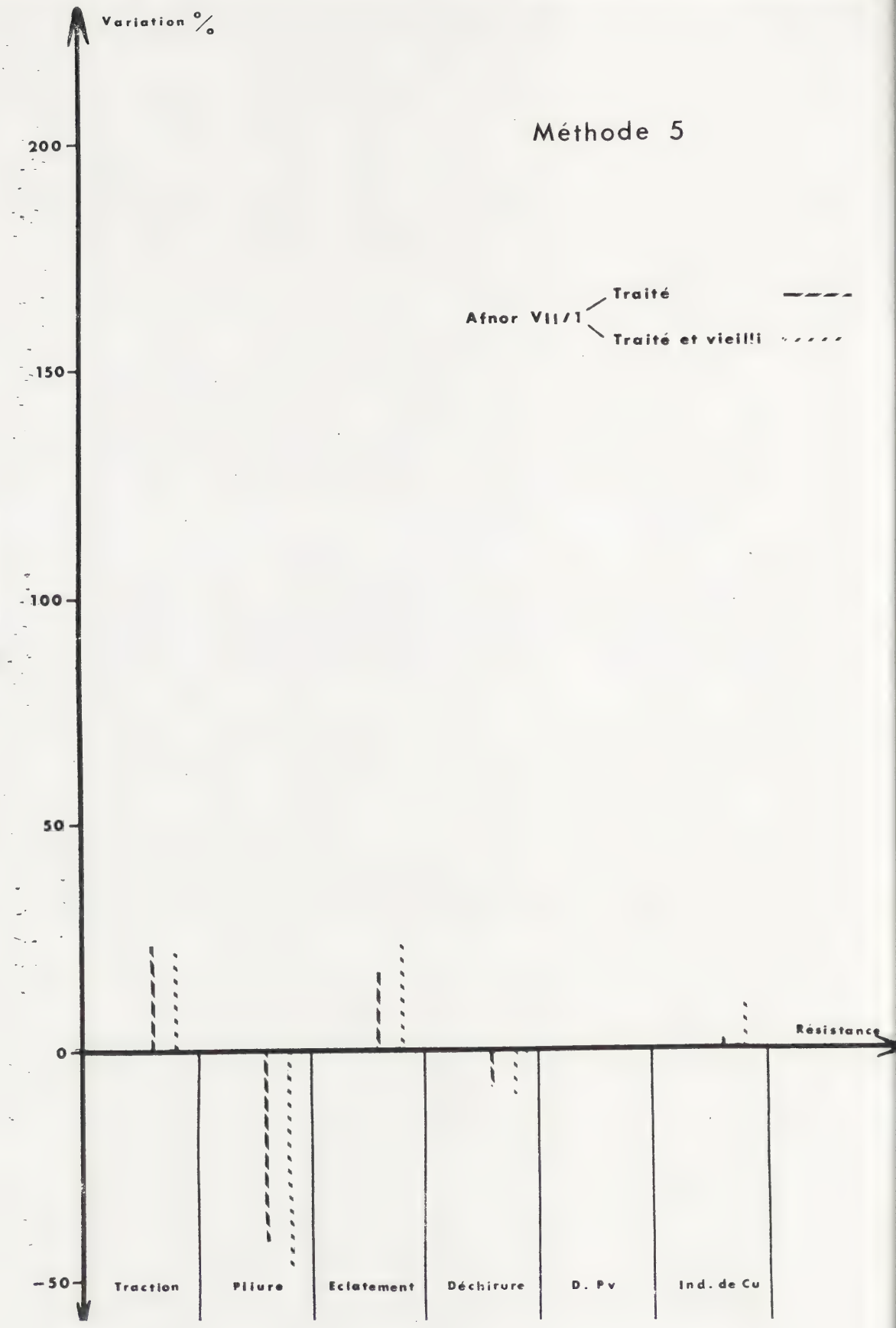
TRAITES PAR LA METHODE 4a

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
NOR VII/4 témoin	2185	3280		* 39	103		17,3		80,1	71,6		77,5	93,5	409		1,32		4,90	1,30
NOR VII/4 traité	2395	3400	+6,6	42	111	+7,6	17,9	+3,4	72	71,3	-5,2	72	95	463	+13	1,31	+0,7	8,25	3,96
NOR VII/4 vieilli	2076	3034		9	14		12,8		64	54,5		64	94,5	376		1,79		4,85	
NOR VII/4 traité vieilli	2440	3520	+8,8	21	43	+209	16,3	+27	73,3	65,6	+17	65	96	445	+17	1,38	+23	8,20	
NOR VII/1 témoin	3618	7310		** 66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,61
NOR VII/1 traité	3800	7400	+3,1	52	49	-34	26,9	-3,1	86,6	78,3	-5,3	77	82	665	-7,3	1,79	0	8,40	4,78
NOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
NOR VII/1 traité vieilli	3800	7660	+21	25	115	+247	26,1	+20	77	66,2	+24	69	84	579	+30	1,93	+16	8,30	

ST = sens travers SM = sens machine Var. = variation

* sous 500 g. ** sous 885 g.


Variation %
Méthode 4 b
200
150
100
50
0
-50
Afnor VII / 4
Traité
Traité et vieilli
Afnor VII / 1
Traité
Traité et vieilli
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu


Variation %
Méthode 5
Afnor VII/1
Traité
Traité et vieilli
200
150
100
50
0
-50
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu

RESISTANCE MECANIQUE ET CHIMIQUE DES PAPIERS AFNOR VII/4 et VII/1

TRAITES PAR LA METHODE 4b

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
AFNOR VII/4 témoin	2185	3280		39	* 103		17,3		80,1	71,6		77,5	93,5	409		1,32		4,9	1,30
AFNOR VII/4 traité	2400	3330	+5,6	39	93	-4,8	16,3	-5,7	82,6	70	-2,2	74	95	454	+11	1,45	-9,8	6,95	2,75
AFNOR VII/4 vieilli	2076	3034		9	14		12,8		64	54,5		64	94,5	376		1,79		4,85	
AFNOR VII/4 traité vieilli	2250	3240	+7,5	15	41	+116	16,3	+27	64,6	56,6	+2,3	63	96,5	417	+11	1,96	-9,4	7	
AFNOR VII/1 témoin	3618	7310		** 66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,6
AFNOR VII/1 traité	3750	7045	-3,6	49	80	-20	27,5	-2,1	87,5	76,6	-5,8	77	81	652	-9,1	1,77	+1,2	8,25	4,30
AFNOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
AFNOR VII/1 traité vieilli	3185	6935	+5,8	34	41	+181	25,7	+18	80	72	+33	66,5	83	573	+29	1,93	+16	8,15	

ST = sens travers SM = sens machine Var. = variation

* sous 500 g. ** sous 885 g.

RESISTANCE MECANIQUE ET CHIMIQUE DU PAPIER AFNOR VII/1

TRAITE PAR LA METHODE 5

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
NOR VII/1 témoin	3618	7310		* 66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,61
NOR VII/1 traité	4415	9160	+23	36	59	-41	33	+17	81,7	77,9	-8	77	76			1,75	+2,2	6,1	2,90
NOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
NOR VII/1 traité vieilli	4075	7112	+21	5	12	-49	26,9	+24	55	50,7	-7,9	66	79			2,06	+10	5,9	

ST = sens travers SM = sens machine Var. = variation

* sous 885 g.

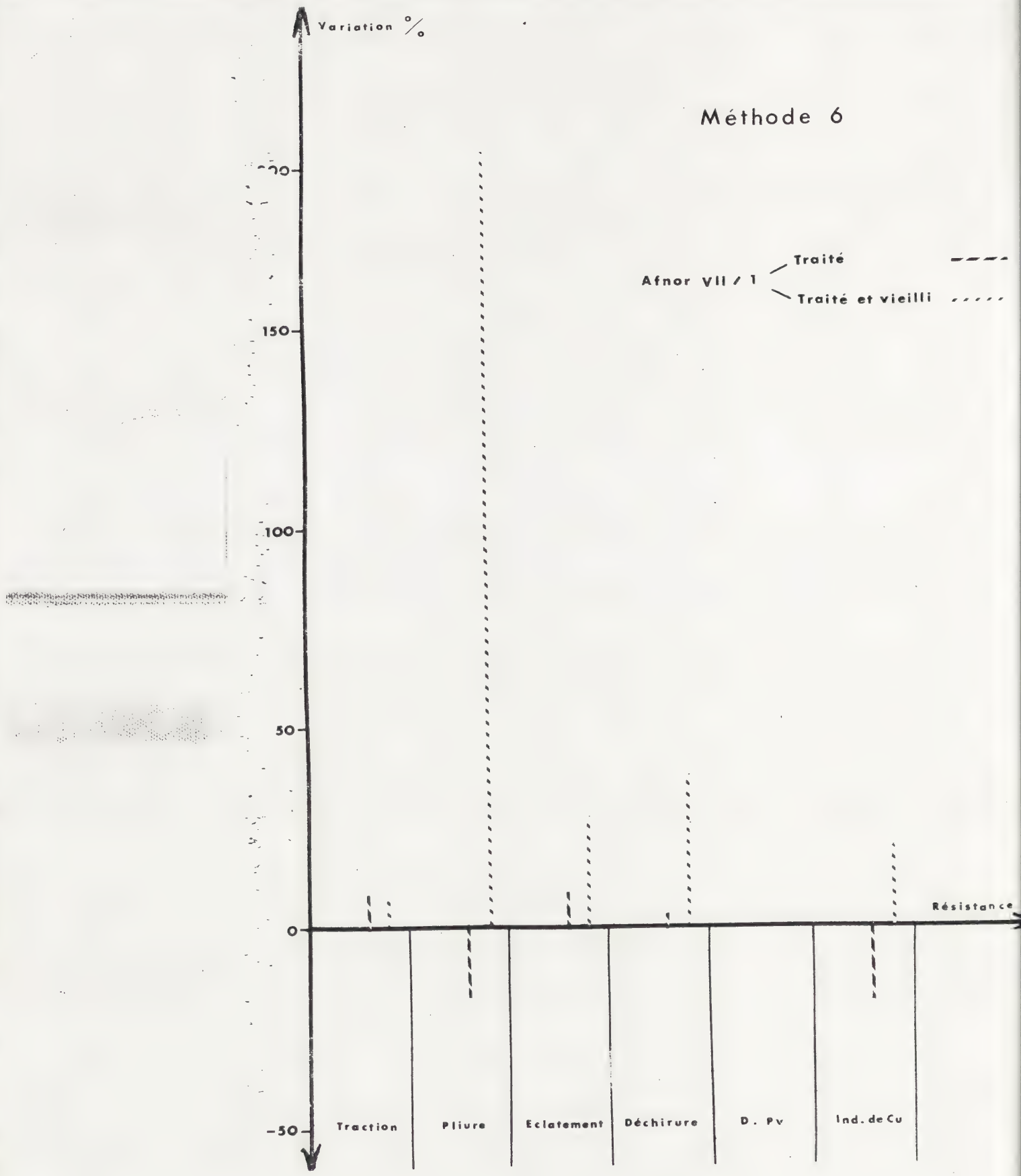
RESISTANCE MECANIQUE ET CHIMIQUE DU PAPIER AFNOR VII/1

TRAITE PAR LA METHODE 6

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
NOR VII/1 témoin	3618	7310		* 66	94		28,1	.	91,6	82,5		78,5	79,5	718		1,79		5,55	2,61
NOR VII/1 traité	3870	8140	+18	60	71	-17	30,6	+ 9	93,7	85	+2,6	74	79,5			2,12	-18	10,4	5,22
NOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
NOR VII/1 traité vieilli	3585	7470	+16	37	44	+204	27,7	+28	82,5	75	+37	72	78,5			1,85	+19	10,3	

ST = sens travers SM = sens machine Var. = variation

* sous 885 g.


Variation %
Méthode 6
Afnor VII / 1
Traité
Traité et vieilli
200
150
100
50
0
-50
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu

A N N E X E

Venant d'achever la première série d'expériences sur deux des techniques décrites par Otto WACHTER et préalablement citées : borax et bicarbonate de soude, nous présentons ici les résultats obtenus avec nos conclusions.

Méthode 10

Les papiers ont été trempés 20 minutes dans une solution à 10 % de bicarbonate de sodium.

Méthode 11

Les papiers ont été trempés 20 minutes dans une solution à 10 % de borate de sodium.

Conclusion

D'après les tableaux et les courbes ci-joints, nous voyons que ces deux traitements sont extrêmement efficaces, le pH des papiers désacidifiés s'échelonnant entre 7 et 8.

Par ailleurs, les deux papiers traités semblent avoir très bien réagi, même après vieillissement artificiel. Le mode opératoire de ces deux techniques est extrêmement aisé, le borax et le bicarbonate de soude étant des produits solubles dans l'eau et vendus à très bas prix dans le commerce. Il n'est donc pas nécessaire, comme pour les sels de calcium et de magnésium, de transformer le carbonate en bicarbonate par barbotage avec du CO_2. On aurait donc tendance à vouloir abandonner les anciennes méthode aqueuses pour ne retenir que ces deux dernières. Néanmoins, il faut être extrêmement prudent, car en théorie l'adjonction de sels de sodium peut avoir des inconvénients très graves. En effet, en atmosphère humide le sodium pourrait s'hydrater et libérer de la soude, ce qui évidemment serait désastreux pour la permanence du papier. Nos expériences réalisées après vieillissement artificiel ne montrent aucune altération des papiers, il faut cependant souligner que le vieillissement a été réalisé dans une étuve sèche, donc sans aucun risque d'hydratation des sels sodiques. Nous désirons maintenant, avant de nous prononcer sur ces deux techniques, vieillir les documents ainsi désacidifiés dans une étuve humide.

RESISTANCE MECANIQUE ET CHIMIQUE DES PAPIERS AFNOR VII_4 et VII_1

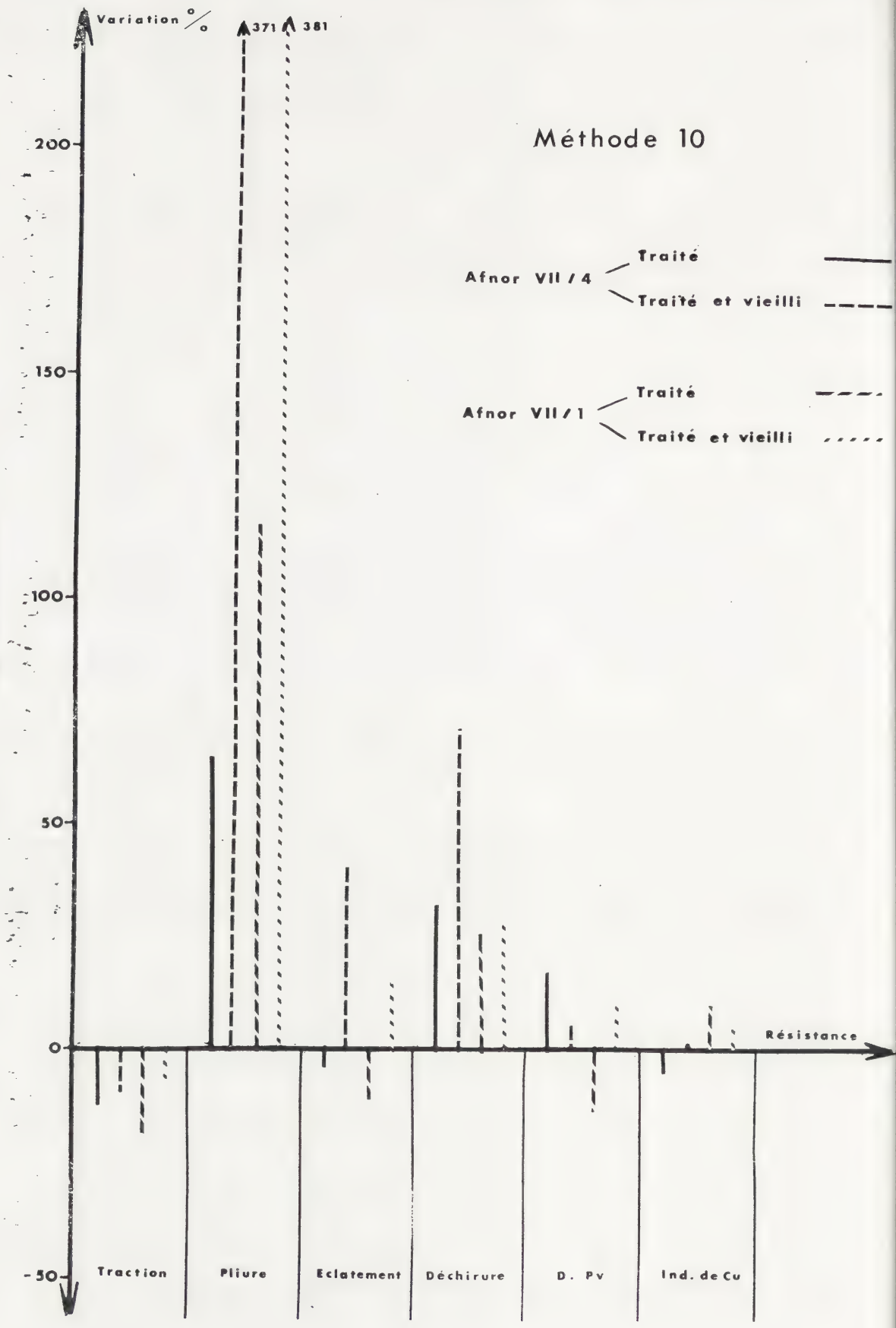
TRAITES PAR LA METHODE 10

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cendres
	ST	SM	Var %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
FNOR VII/4 témoin	2185	3280		*39	103		17,3		80,1	71,6		77,5	93,5	409		1,32		4,9	1,30
FNOR VII/4 traité	1990	2795	-12	68	158	+64	16,7	-3,4	122	108	+32	74,5	89	479	+17	1,38	-4,5	7,45	1,43
FNOR VII/4 vieilli	2076	3034		9	14		12,8		64	54,5		64	94,5	376		1,79		8,85	
FNOR VII/4 traité vieilli	1865	2800	-8,9	38	73	+371	18	+41	102	93,3	+70	63	95	395	+ 5	1,77	+1,1	7,45	
FNOR VII/1 témoin	3618	7310		**66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,61
FNOR VII/1 traité	3410	5115	-18	94	203	+116	25,1	-11	102	90	+27	75	76	622	-13	1,61	+10	8,6	2,60
FNOR VII/1 vieilli	2142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
FNOR VII/1 traité vieilli	3010	5830	-5,7	45	120	+381	25,1	+16	84	69,5	+29	58	84	499	+12	2,14	+6,9	7,95	

ST = sens ravers
* sous 500 g.

SM = sens machine
** sous 885 g.

Var. = variation

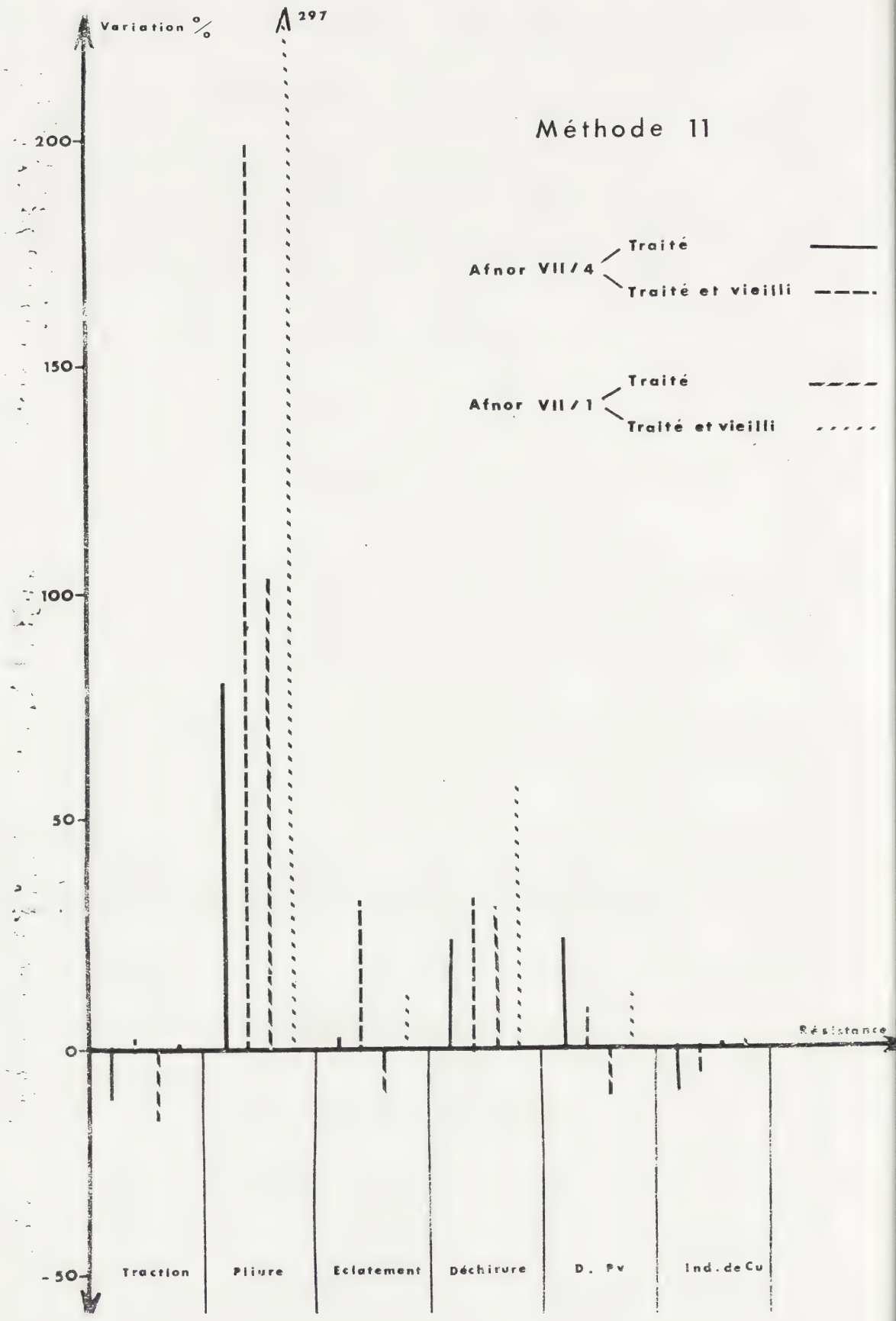

Méthode 10
Variation %
371
381
200
150
100
50
0
-50
Afnor VII / 4
Traité
Traité et vieilli
Afnor VII / 1
Traité
Traité et vieilli
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu

RESISTANCE MECANIQUE ET CHIMIQUE DES PAPIERS AFNOR VII_4 et VII_1

TRAITES PAR LA METHODE 11

	Longueur de rupture en mètres			Résistance à la pliure			Indice d'éclatement		Indice de déchirement			Degrés		D.P.v.		Indice de cuivre		pH	Cen dr
	ST	SM	Var. %	ST	SM	Var. %		Var. %	ST	SM	Var. %	Blancheur	Opacité		Var. %		Var. %		
AFNOR VII/4 témoin	2185	3280		*39	103		17,3		80,1	71,6		77,5	93,5	409		1,32		4,9	1,3
AFNOR VII/4 traité	2020	2830	-11	62	208	+80	17,7	+2,3	93	93,7	+23	78	89	505	+23	1,45	-9,8	7,4	1,4
AFNOR VII/4 vieilli	2076	3034		9	14		12,8		64	54,5		64	94,3	376		1,79		4,85	
AFNOR VII/4 traité vieilli	2104	3135	+2,3	25	45	+199	17	+33	87	84	+33	66	95	407	+8,2	1,89	-5,6	7,05	
AFNOR VII/1 témoin	3618	7310		**66	94		28,1		91,6	82,5		78,5	79,5	718		1,79		5,55	2,
AFNOR VII/1 traité	3215	5808	-16	76	274	+103	25,2	-10	114	113	+31	80	76	643	-10	1,79	0	8,6	3,
AFNOR VII/1 vieilli	3142	6286		8	30		21,7		60,8	54,1		65	82	445		2,30		5	
AFNOR VII/1 traité vieilli	3325	6008	+0,7	46	66	+297	24,5	+13	96,6	85	+58	69	82	505	+14	2,27	+1,3	8,2	

ST = sens travers SM = sens machine Var. = variation


Variation %
297
Méthode 11
Afnor VII/4
Traité
Traité et vieilli
Afnor VII/1
Traité
Traité et vieilli
200
150
100
50
0
-50
Résistance
Traction
Pliure
Eclatement
Déchirure
D. Pv
Ind. de Cu

LABORATOIRE D'ETUDE DES OEUVRES D'ART PAR LES METHODES SCIENTIFIQUES
UNIVERSITE CATHOLIQUE DE LOUVAIN

LA RADIOGRAPHIE EN COULEURS APPLIQUEE A L'ETUDE DES OEUVRES D'ART

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L'utilisation de la radiographie en couleurs est étudiée depuis longtemps dans le domaine médical et industriel. Le but de la présente communication est de signaler un certain nombre d'étapes dans l'usage de la radiographie en couleurs dans les domaines précités et de montrer les premiers résultats que nous avons obtenus par l'application de ces techniques aux oeuvres d'art et principalement aux peintures.

A P E R C U H I S T O R I Q U E

L'aperçu historique comprend trois parties : la radiographie en couleurs simulées, la radiographie directe en couleurs et la radiographie monochromatique.

RADIOGRAPHIE EN COULEURS SIMULEES

A notre connaissance c'est en 1926 que l'on signale pour la première fois la radiographie en couleurs simulées. COURCOUX et GIBSON (1) utilisent des écrans de tailles et de couleurs différentes pour l'examen de radiographies pulmonaires. Ils prennent un écran vert pour les images claires ou grises, dont le contraste est ainsi renforcé. Ils emploient un écran jaune pour les images au contraste trop élevé; ils suppriment ainsi l'éblouissement

causé par les zones trop blanches et permettent un éclairage intensif qui pénètre les zones noires.La même année PHILLIPS (2) obtient une image radiographique rouge ,en utilisant un écran fluorescent verdâtre.Projettant une lumière rouge sur cet écran ,il produit une impression blanche.Un objet situé entre la source de radiations et l'écran ,dessine une image rouge.Comme l'effet blanchâtre provoqué par l'addition du vert et du rouge est supprimé dans cette zone,seule la lumière rouge apparaît.

Oralement en 1949 ,puis par écrit en 1951,DONOVAN (3) montre qu'une radiographie colorée présente sur une seule image les informations de deux ou plusieurs radiographies noir et blanc ,dans une forme naturellement attrayante pour l'oeil.Pratiquement il part de radiographies en noir et blanc et se basant sur la théorie des trois couleurs primaires,il utilise tantôt la méthode additive pour la projection,tantôt la méthode soustractive pour l'impression sur papier de l'image colorée.Des essais ont également été réalisés avec deux couleurs seulement.Des radiographies en couleurs de ce type sont particulièrement intéressantes pour l'étude des tissus mous,dont elles révèlent non seulement l'aspect externe mais également l'aspect interne qui reste lui aussi parfaitement discernable.

PIRKEY et PARKER en 1950 (4) se préoccupent de l'aspect didactique de la présentation des radiographies. Les étudiants n'arrivent que difficilement à mettre en relation ce qu'ils voient avec leurs connaissances théoriques d'anatomie et de pathologie.Après plusieurs recherches dans diverses directions ,Pirkey et Parker mettent au point un procédé de coloration manuelle.Au départ de la radiographie en noir et blanc ,un négatif ordinaire est pris. Ce négatif est ensuite imprimé par contact ou par agrandissement sur un film FLEXICHROME.Ce film est développé

normalement .Après le développement et le bain d'arrêt,le film est placé en eau chaude où la gélatine de l'émulsion fond en partie,de manière inversément proportionnelle à la quantité de grains d'argent réduits.On obtient alors une sorte d'image en bas-relief avec une épaisseur d'émulsion plus grande dans les zones sombres et plus faible dans les zones claires . Après séchage , l'image est prête pour la coloration au moyen des teintes adéquates.Le résultat obtenu est alors photographié sur un film couleurs de 35 mm. et, après traitement ordinaire,les documents sont montés en diapositives.

En se basant sur les travaux de Pirkey et Parker, DOWDY et BONANN (5) présentent en 1953 une amélioration de la méthode.Ils utilisent non plus le film FLEKICHROME mais un film MATRIX pour réaliser l'image en bas-relief destinée à être colorée.En 1958 BONNAN et DOWDY (6) présentent une dernière amélioration du procédé.Ils préconisent pour la réalisation du premier négatif ,dont la qualité est essentielle -puisqu'à la base de cette technique-l"utilisation d'un LOGETRON.Le procédé du LOGETRON permet d"obtenir une reproduction fidèle et,grâce à l'automatisation et à la standardisation du système ,de supprimer de nombreux facteurs de variabilité.Ils utilisent toujours le film MATRIX ou Pan-MATRIX.Le but final reste également didactique.

Dans le domaine de l'angiographie,DJINDJIAN (7) présente en 1964 le procédé de VULMIERE qui,se basant sur la méthode de soustraction de ZIEDSES DES PLANTES ,réalise une différenciation optique de deux clichés radiographiques au moyen de deux négatoscopes munis chacun d'un rhéostat et de filtres colorés (rouge pour l'un, vert ou bleu pour l'autre).Avec MARTIN (8), il présente une nouvelle méthode qui améliore encore la différenciation des réseaux artériels et veineux par la transposition photographique en 2 couleurs.

LILIEQUIST et WELANDER (9) reprennent et améliorent le procédé de Martin,mais utilisent trois couleurs.Pratiquement ils superposent trois angiogrammes représentant des phases différentes de la circulation du sang.Des radiographies en noir et blanc,ils tirent trois copies,l'une en jaune,l'autre en magenta ,la dernière en cyan.

En 1967 ,BÖCK (10) montre qu'il est possible de réduire dans une proportion de 50 à 60 % le produit MA s . Il indique en effet que même le développement en couleurs de radiographies sous-exposées donne des informations comparables à celles de documents noir et blanc correctement exposés.

RADIOGRAPHIE DIRECTE EN COULEURS

La radiographie directe en couleurs se distingue de la radiographie en couleurs simulées par le fait qu'il ne s'agit plus de transformer la vision d"un document radiographique original noir et blanc en impression colorée ,mais directement de soumettre aux radiations un film couleurs, sensible aux rayons X.L'image colorée obtenue ne reproduit pas les couleurs originales de l'objet irradié mais des intensités de radiations.

En 1938 ,VALLEBONA (11) montre l'intérêt de soumettre directement aux rayons X un film couleur(Agfa Color), avec ou sans écran renforcateur.

C'est en 1948 que BERGERHOFF (12) insiste sur le fait que"le nombre de détails de densité discriminable par l'oeil humain en couleurs dépasse celui en noir et blanc". Ceci est particulièrement valable pour les couleurs situées à proximité du maximum de la sensibilité de l'oeil.

Suite à des travaux communs de BERGERHOFF,MILLER et EICHLER ,le dernier nommé (13) présente en 1956 l'état des recherches pour réaliser des films recouverts de plusieurs couches d'émulsions colorées dont le traitement ne serait pas plus compliqué qu'un traitement de radiographies en noir et blanc.Des essais ont été faits avec des films portant des deux côtés l'émulsion de base plus des composants colorés.La recherche a ensuite porté sur la réalisation en une émulsion commune des divers éléments.Il ne s'agit pas de solutions finales directement exploitables commercialement mais d'essais en laboratoire.

En 1960,BERGERHOFF (14) présente un support comportant deux émulsions chromogènes différentes avec des courbes de gradation identique.En outre ce support peut être coloré dans une troisième couleur.Ce nouveau film en couleurs est principalement préconisé pour la technique de l'encéphalographie.Ces radiographies en couleurs peuvent être examinées dans un négatoscope muni de jalousies et d'un éclairage d'intensité variable.

Déjà en 1958 ,BONAHN (15) avait reconnu l'importance des recherches menées pour trouver la composition idéale d'émulsions couleurs sensibles aux rayons X.

Egalement intéressés par la radiographie directe en couleurs,BLAIS et SCHWERIN (16),présentent en 1955 une formule toute différente:ils placent un film couleurs normal (de préférence négatif)entre deux écrans renforcateurs spéciaux,exposés ensuite de façon classique au rayonnement.Ces écrans différents l'un de l'autre ,produisent une lumière fluorescente lorsqu'ils sont soumis aux rayons X.Comme l'intensité fluorescente dépend à la fois du caractère quantitatif et qualitatif de la radiation absorbée,la couleur qui en résulte dépendra également de l"intensité et de la composition spectrale du rayonnement.

En 1964 ANGERSTEIN,KRUG et RAKOW (17) reprenant l'ensemble des procédés d"obtention de radiographies couleurs ,exposent en détails la technique de KANKELWITZ de 1960 (18) de transformation d"un cliché photographique noir et blanc en une image couleurs.Cette technique sera appliquée à la radiographie par RAKOW,ANGERSTEIN ,KRUG et KANKELWITZ et présentée avec HEICHORN en 1961 au congrès de radiographie de Hambourg (19 ,20).Les auteurs utilisent deux ou trois couleurs élémentaires :le bleu,le pourpre et le jaune. Le cliché noir et blanc étant à nouveau "halogénisé " avant de subir un nouveau développement,chromogène cette fois.

Ayant appliqué ce procédé avec succès à la radiographie thoracique,CHEVROT et collaborateurs (21) insistent en 1969 sur la meilleure captation de l'intérêt des étudiants ,sur une plus grande rapidité dans le diagnostic et sur la simplicité du procéde.

Dans le domaine industriel BEYER (22) montre l'intérêt de documents couleurs pour la radiographie d'objets métalliques qui présentent des caractères de densité nettement plus élevés que les tissus et le squelette humain. Il a notamment appliqué le procédé à de minces feuilles d'uranium dont les diverses caractéristiques deviennent clairement apparentes.

Confirmation de cet intérêt est donné par PARISCH et PULLEN (23) ,par OSTROFSKY (24) et par BEYER (25).Ces diverses études présentent des exemples de radiographie industrielle pour des contrôles de qualité.Des justifications et mesures théoriques du procédé sont exposées de façon détaillée par RICHTER et LINKE (26) et par PRINZ , KATZ et BILLMEYER (27).De cette dernière étude il apparaît clairement que la radiographie en couleurs contient une plus grande quantité d'information que la radiographie en noir et blanc.

RADIOGRAPHIE MONOCHROMATIQUE

D'autres recherches ont montré que l'introduction d'une seule couleur dans la radiographie était suffisante pour atteindre cette augmentation d'informations recherchée. La radiographie monochromatique offre en outre l'avantage d'un développement plus aisé.

En 1967 ,BLANC (28) présente les premières recherches de radiographies monochromatiques.

BOEHNES en 1969 (29) réalise des travaux en utilisant une pellicule bleu-violet . Il insiste sur la latitude d"exposition du film et la haute définition des clichés.Il n'est cependant pas certain que le résultat ainsi obtenu est le meilleur.Il estime que de nouveaux essais permettront de déterminer la couleur la plus efficace.En 1970 (30),le même auteur montre que le contraste de l'image peut être augmenté à volonté en modifiant la composition spectrale de la lumière du négatoscope ou en utilisant des filtres colorés.

Divers documents sur pellicule monochrome bleue sont également présentés par COLLARD(31) qui en montre l'avantage par rapport aux pellicules traditionnelles , qu'elles soient vues en lumière normale ou à travers des filtres colorés.Un jeu de quatre filtres allant du jaune clair à l'orange foncé est disponible.

Les avantages réels du procédé sont confirmés par ZEITLER et HÜRING (32) qui insistent sur l'absence de grain , la résolution analogue à celle de la radiographie en noir et blanc et la grande latitude d'exposition. Concernant ce dernier point ,on peut en effet considérer que la tolérence d'erreurs est deux fois plus grande que dans le cas d"un film noir et blanc.Les domaines évoqués par ces auteurs relèvent de l'angiographie,de la radiographie thoracique et de l'artériographie.

La radiographie monochromatique a également été appliquée avec succès à la mammographie par LAMARQUE,GINESTE et VIALA (33).

A P P L I C A T I O N S

Un tableau anonyme flamand du XVIIe s. a été choisi comme exemple de radiographie en couleurs simulées et de radiographie directe en couleurs.

RADIOGRAPHIE EN COULEURS SIMULEES

Une radiographie originale en noir et blanc (STRUCTURIX D.7) a servi pour réaliser une impression par contact sur film COPY-COULEURS. Au cours du développement, le document est retiré du bain de révélateur, après la moitié du temps normalement préconisé, et exposé sous une lampe munie d'un filtre coloré - pour ces essais, on a successivement employé un filtre jaune, un filtre cyan et un filtre magenta -, puis le développement est poursuivi et achevé normalement.

Dans les trois cas, les résultats sont relativement semblables. Ils donnent une image haute en contraste par rapport à la radiographie originale en noir et blanc qui présentait un noircissement assez faible.

RADIOGRAPHIE DIRECTE EN COULEURS

Le même tableau a été utilisé pour des essais de radiographie directe en couleurs. Le film employé est l'AGFACOLOR POSITIF M normalement réservé aux arts graphiques. Ce film, à grain très fin, présente moins de contraste que le STRUCTURIX et son développement nécessite un traitement

destiné à la couleur.

Trois essais ont été réalisés. Les deux premiers avec exposition sous filtre magenta, en cours de développement. Ces deux essais ont été effectués dans les mêmes conditions mais le temps d'exposition a varié: 6 minutes pour l'un et 12 minutes pour l'autre. Un troisième essai a été réalisé avec exposition sous filtre jaune pendant le développement.

Les documents obtenus avec filtre magenta sont très nuancés et permettent de lire facilement les divers détails. Il n'existe pas de différence sensible dans les résultats obtenus en variant les temps d'exposition. L'image obtenue avec le filtre jaune met surtout en évidence les zones de forte densité qui apparaissent sous forme de plages sombres tandis que les zones de faible densité sont moins aisément perceptibles.

Pour des raisons d'ordre technique, les essais n'ont pu être poursuivis sur ce plan.

RADIOGRAPHIE MONOCHROMATIQUE

L'attention du laboratoire a surtout porté sur l'emploi de la radiographie monochromatique. Les films médicaux BLUE TYPE HL de 3M et MEDICHROME d'Agfa-Gevaert ont été utilisés.

Outre le tableau déjà utilisé précédemment, les exemples retenus sont : en peinture, une Vierge en buste sur toile du XVIIe s., une marine du XIXe s. sur toile et un tableau italien, sur bois et parqueté, du XVIe s.; comme objet métallique, un couvercle en bronze mésopotamien et en sculpture, un bas-relief en bois.

La pellicule BLUE TYPE HL, qui présente les mêmes caractéristiques de sensibilité et de traitement que les films noir et blanc de cette firme, offre néanmoins l'avantage de pouvoir être traité sous un éclairage inactinique plus intense.

Le film MEDICHROME, à émulsion bleutée, nécessite des conditions de développement particulières tenant aux produits de traitement et à la température. Son contraste peut être modifié par la lecture au moyen de filtres ou d'un négatoscope colorés.

Se basant sur les fiches techniques des différents films et après ajustement nécessité par l'application aux oeuvres d'art, les rapports de sensibilité, par référence au film STRUCTURIX D.7 employé généralement pour le noir et blanc, sont les suivants:

MEDICHROME : temps d'exposition multiplié par 2.
BLUE TYPE HL : temps d'exposition multiplié par 12.

On remarquera que les documents 3M et MEDICHROME sont parfaitement lisibles et, dans les cas retenus, donnent une quantité d'informations analogues à celles de la radiographie en noir et blanc.

A l'actif du BLUE TYPE HL, on retiendra les possibilités de développement dans des produits utilisés pour la radiographie traditionnelle. Par contre, on remarquera l'augmentation nécessaire de la durée des temps d'exposition.

Le MEDICHROME ne nécessite pas de caractéristiques particulières d'exposition mais emploie des produits spéciaux pour le développement.

Un des avantages les plus notables du MEDICHROME réside dans la grande latitude d'exposition de ce film. On s'en rendra compte dans les documents suivants:

Vierge en buste :	1/	B	2 min
		A	1 min
	2/	D	6 min
		C	3 min
	3/	F	8 min
		E	4 min

On constate que l'on fait varier, intentionnellement et de façon considérable, les temps d'exposition. Malgré cela, chacun des documents garde une lisibilité raisonnable. Le résultat le meilleur est obtenu par 1 min.
On a pris ici, comme élément de référence, un document en STRUCTURE D.4 de 2 min.

Dans le cas du couvercle métallique, les films bleutés n'apportent pas d'indications nouvelles. Le document MEDICHROME montre toutefois des nuances plus marquées qui permettent un contrôle plus rigoureux des qualités de l'objet.

On a vu que l'emploi de filtres ou d'un négatoscope colorés était recommandé pour la lecture de radiographies sur film MEDICHROME.

Les documents suivants présentent des cas comparés de radiographies en noir et blanc, de radiographies MEDICHROME et de radiographies MEDICHROME vues à travers filtre. Ces comparaisons ont été réalisées pour des radiographies normales, des stratiradiographies et des stéréoradiographies.

Dans les divers cas, l'enrichissement de l'image sur film MEDICHROME est évident. Des indications nouvelles apparaissent dans des zones non contrastées en radiographie noir et blanc. Des zones de faible densité révèlent des nuances insoupçonnées. Les zones fortement chargées de blanc de plomb, ayant l'aspect de masses homogènes, présentent sur

film MEDICHROME de nombreuses différenciations qui informent de manière beaucoup plus complète sur l'état réel des densités. L'emploi du filtre jaune clair donne, dans la plupart des cas mais surtout dans le cas des contrastes faibles, un réel approfondissement de l'image.

Nous adressons nos remerciements pour leur précieuse collaboration aux firmes AGFA-GEVAERT de Mortsel (Anvers) et BALTEAU de Beyne-Heusay (Liège). Ces firmes nous ont prêté des documents ou en ont réalisé à notre demande.

La majorité des documents d'application aux oeuvres d'art a cependant été réalisée par le Laboratoire d'étude des oeuvres d'art par les méthodes scientifiques de l'Université catholique de Louvain.

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IDENTIFICATION OF WORKS OF ART BY MEANS OF AN OPTICAL COMPARATOR

by

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Abstract

The ability to produce a unique record of a work of art to enable an accurate comparison to be made at any subsequent time is important in the contexts of restoration, examination, identification, insurance, and cataloguing of works of art. A project to investigate optical techniques for such purposes has recently been completed with the construction and evaluation of a prototype optical comparator. The major emphasis has been placed upon paintings and drawings, but the examination of 3-dimensional works such as sculptures is also possible. A straightforward comparison of photographs of object and original proved to be the simplest and most reliable technique, with the advantage that it is applicable to almost all classes of works of art.

In the optical comparator which has been constructed two photographic negatives are imaged through independent optical channels onto the same image plane for comparison in a number of ways. These two negatives are photographs of the original and the object to be examined, taken using the comparator as a camera with recorded lens position and illumination configuration. To ensure that both photographs are taken of the same aspect of the object, the comparator is used in a mode in which the object is imaged live via one channel and the original record via the other channel. Thus simultaneous viewing of object and record enables the object to be correctly oriented before taking a photograph. Using a Polaroid Camera back positioned at the image plane a second negative is then taken for accurate comparison with the original record. By mounting one negative on a manipulator the relative position and rotation of the two images may be adjusted for superposition. The images may be viewed under magnification, and a comparison made to a degree of accuracy chosen by the operator and consistent with the type of work being treated. The prototype comparator has been successfully tested using a variety of works of art. At present all records are taken using black and white film, although colour filtering techniques are used to simplify the ultimate comparisons.

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1. Introduction

The general concept of making a unique record of a work of art to enable its positive identification at any subsequent time is one which appears to have received little attention in the past. Such records would, for example, be highly desirable for insurance purposes and for detailed cataloguing of works of art, as well as for general work concerned with the examination and restoration of works of art. This report describes the results of a feasibility study of the use of a straightforward optical technique for the production of such a record and for the authentification of the object at a later date. The term "work of art" is taken to cover both solid objects such as sculptures and glassware, and essentially two-dimensional objects such as paintings and drawings.

Non-destructive techniques for identification are necessarily based upon a comparison of the record and object to be identified either in general topography, outline, or detail in specific areas. Identification can therefore be affected by any change in these parameters between making the original record and subsequent identification of the object. Such changes can arise from variations in temperature and humidity, and an effort should therefore be made for all recording and identification to be carried out in a controlled environment, and to allow sufficient time for the object to adjust to this environment. Dimensional changes resulting from handling and cleaning cannot be avoided, and their importance depends upon the accuracy to which the record and object are compared and must be considered for any technique employed.

Section 2 contains a detailed account of the construction of an optical comparator which is designed to meet the requirements for identification. Sections 3 and 4 describe how this comparator may be used in the identification of various types of works of art.

2. Identification Using an Optical Comparator

2.1 General design considerations

The optical comparator described in this section is designed to provide the two basic requirements for identification, namely

a) a means of comparing photographs of the original and the object to be identified,

b) a means of aligning the object to ensure that all photographs for identification purposes are taken from an identical viewpoint.

The straight-forward comparison of photographs of original and object was found to be the simplest and most reliable of the identification techniques considered. Other optical techniques, such as the comparison of Fourier transforms or the projection of linear fringes onto the object to give a contour-map photograph, all suffer from severe object alignment problems and are far less flexible than the approach described here.

Flexibility in use is an important consideration in the design of the comparator. The operator must be able to allow for small, identifiable changes in the object which may be inevitable over a period of time. Examples would be small, regular dimensional changes and the appearance of new cracks in paintings, and perhaps even the complete removal of small areas of paintings and solid objects. Thus a highly accurate one-to-one correspondence over the whole area of photographs of object and original is not required for practical identification. What is required is the existence of similarities which could not reasonably be reproduced by copying and the accurate correspondence of certain areas which may form only a small part of the total object.

The optical comparator which has been designed to meet these requirements is

shown schematically in Figure 1. Basically it consists of two independent optical channels which serve to image the photographic negatives with unit magnification onto the same image plane for comparison in a number of ways. Further, by removal of the prism in channel 2, any object may be imaged onto this plane, where it may be viewed simultaneously with a negative in channel 1; this facility enables the orientation of the object to be adjusted until identical with that used when making the negative. Since the image is reversed in channel 2 by reflection at the pellicle, the negative in channel 1 must be inserted back to front. Insertion of a Polaroid back at the image plane enables either a positive print of a negative transparency to be taken.

Thus a photographic negative constitutes the record of the object. Identification is then achieved by a comparison of the record and a second photographic negative taken of the object under the same conditions, or alternatively by a direct comparison of record and object.

2.2 Detailed description

The individual components of the comparator will now be described in more detail, with general reference to the schematic layout shown in Fig. 1.

a) Photographic negatives

The photographs to be compared are intended to be in the form of Polaroid black and white negatives (5 x 4 inch pack film, type 55 P/N); this film gives both a negative transparency for use in the comparator and a positive print which is useful for immediate evaluation of the photograph. Since the records must be kept for a considerable period of time, the negatives must be carefully processed

THE OPTICAL COMPARATOR

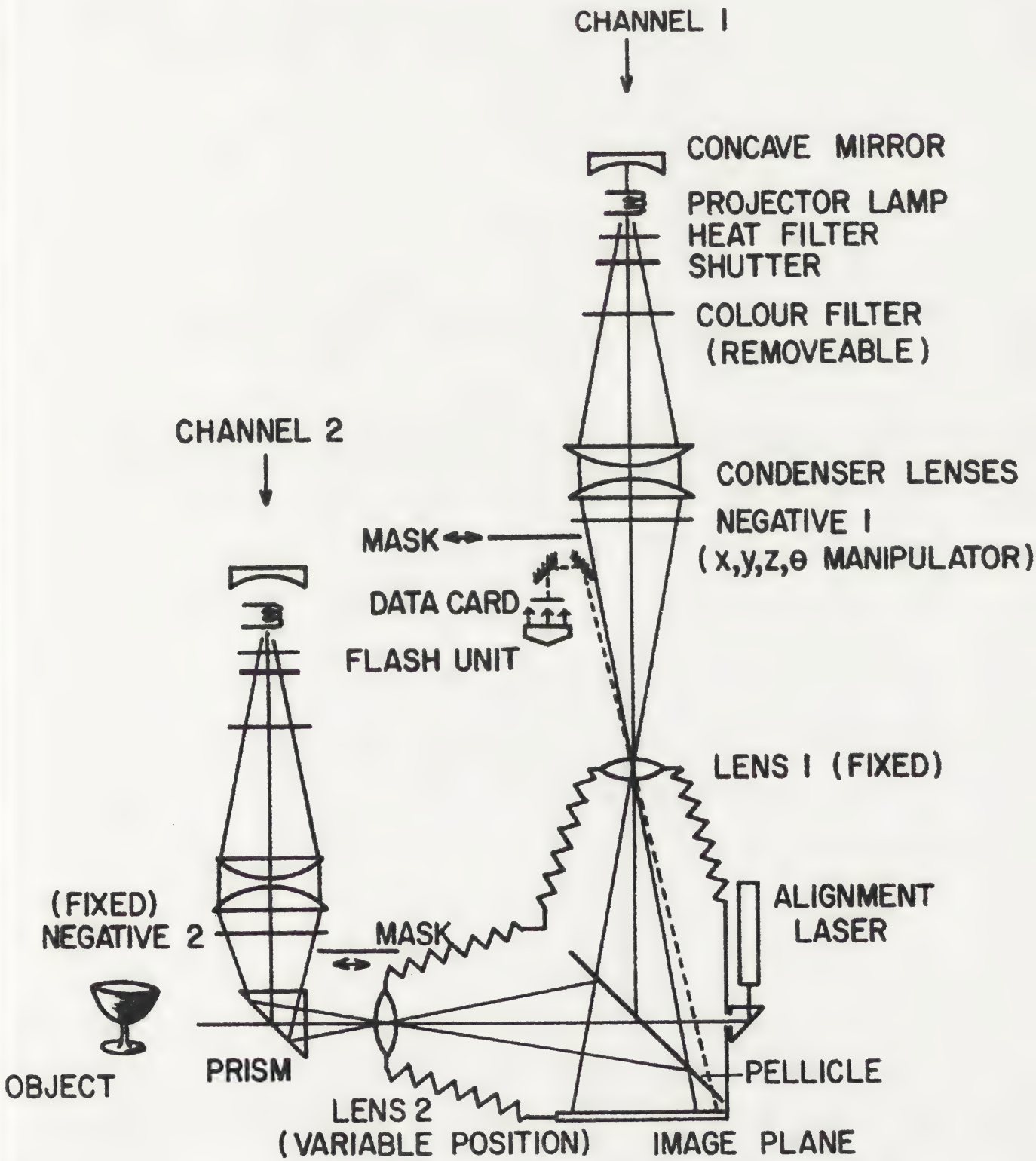


Fig. 1

in a clearing and a hardening bath in accordance with the procedure recommended by Polaroid. If correctly processed and stored in a cool, dry environment the negatives should stay in good condition for periods in excess of 30 years.

For use in the comparator each negative is held in a special mount, in which the negative is sandwiched between two flat, thin glass plates. These mounts then slot easily into the comparator at the correct locations.

b) Manipulator

The negative in channel 1 is mounted on a manipulator so that the position of its image may be adjusted for coincidence with the image of the negative in channel 2. The manipulator enables horizontal and vertical movements of the negative through about 2 cm and a rotation in the plane of the negative of up to 15° either side of the vertical position. The negative may also be moved either towards or away from the lens to change the effective magnification of the image in order to accommodate a small difference in scale between negatives 1 and 2. If such an adjustment is required the depth of focus must be increased by reducing the lens aperture in order to maintain a sharp image.

The four micrometers which control the manipulator movements are driven by small electric motors, so that the manipulator may be fully operated from a remote control box. Course or fine adjustment is possible and microswitches automatically cut off the motors at the extremes of each movement. The manipulator is normally positioned such that a magnification of exactly unity is achieved when the negative is as close to the lens as allowed by the movement. Thus when comparing negatives of slightly different scale, the larger scale negative should always be inserted in channel 1.

c) Masks

The purpose of the sliding masks is to provide a split field facility in which a portion of the observed field is derived from one negative and the remainder of the field from the other negative. Each mask ends as a vertical knife-edge positioned about 5 mm from the negative and is driven horizontally across the negative by a small electric motor to allow remote control. In addition to coarse and fine controls for positioning the masks, a separate switch can be used to withdraw a mask completely to enable the whole negative to viewed.

d) Illumination

Identical illuminating optics are used for each channel. The light source is a 250 watt projection lamp, and the negative is positioned immediately in front of the condensing lens which produces a converging beam of light coming to a focus at the imaging lens. A concave mirror positioned behind the projection lamp is used to increase the illumination efficiency. The lamp is cooled by a small fan, and a heat filter is required in the illuminating beam.

The intensities of the two lamps may be varied independently from the control box. The illumination in each channel may be interrupted by a shutter, and the facility exists to change the field of view rapidly from one negative to the other by using a single switch to reverse the shutter configuration. Different colour filters may be inserted in each channel to facilitate comparison of the negatives.

e) Lenses

The two lenses used to image the negatives are identical and of the Symmar class made by Schneider. The lens in channel 1 is fixed in position and images

the negative with a magnification of exactly unity. The position of the lens in channel 2 may be varied. For comparing negatives this lens is also positioned to give unit magnification. However, for imaging an object when making a photographic record or for live identification the prism in channel 2 is removed and the lens is positioned according to the magnification required. For objects of dimensions greater than about 25 cm the focal length of the lens must be increased either by unscrewing the front section, or by changing to the other lens provided. The two lenses for channel 2 are chosen to provide all required values of magnification. The lens shutters may be operated from the front of the comparator via cable releases. Setting the shutters, apertures and speed has to be done manually before taking a photograph.

f) Pellicle

Light from the two channels is combined near the image plane by a six inch diameter pellicle (purchased from the National Photocolor Corporation). The pellicle consists of a thin membrane stretched over a rigid frame and has a special coating to give 40 % transmission and 40 % reflection over the visible spectrum. The pellicle is flat to a few wavelengths over the central 80 % of its area, and as the thickness is only 8 μm the reflections from the front and back surface are effectively superimposed and only a single reflected image is observed.

As the pellicle is difficult to clean it is mounted in a dust tight box with thin glass windows for the light input from the two channels and output to the image plane. The lenses are connected to this box by flexible bellows and the Polaroid back fits on directly, so that the whole unit effectively forms a light-tight camera.

g) Image plane

The images may be viewed at the image plane using a fresnel lens in contact with a diffusing screen. For viewing the images under magnification the lens-screen combination can be removed and a binocular viewing system moved to the image plane. The magnification can be varied by changing the binocular eyepieces and the unit is mounted to allow horizontal and vertical movement covering the whole image plane.

Any image displayed at the image plane may be photographed by insertion of a Polaroid back which can be used with Polaroid 4 x 5 inch pack films. The most useful film is type 55 (positive/negative) which is used for making all negative transparencies and also for taking positive prints of objects or negatives when required. Types 57 (high speed), 52, 51 (high contrast) and 58 (colour) pack films may also be used for making positive prints of objects or recording the image plane display during identification.

h) Objects and illumination

Removal of the prism in channel 2 enables an object positioned in the area indicated in Figure 6 to be imaged with suitable magnification onto the image plane. For paintings and solid objects positioned close to the lens, illumination can be provided either by two concentric, ring fluorescent tubes on a vertical plate with a central hole through which the lens views the object, or by suitable oblique illumination positioned to one side of the lens. The positions of the lens and illumination plate and the object-lens distance may be adjusted to give the required magnification at the image plane. For objects positioned further from the lens, illumination is provided either by larger fluorescent tubes or by

flood-lamps at suitable positions. When making a photographic record the type and angle of illumination must always be recorded. A mount for small objects is built onto the comparator; larger objects are mounted separately.

i) Alignment laser

A small alignment laser has been included in the comparator design. Although not an essential component, the laser greatly facilitates alignment of the optics both during the initial setting up and also at any subsequent realignment required after cleaning. Further, the laser helps positioning of objects in channel 2 since the narrow light beam represents a projection of the optical axis in space. A suitable laser would be a low power (0.5 mW) Helium-Neon laser.

j) Data flash

Information about the object under investigation, date and other relevant parameters is imaged by the lens in channel 1 onto one side of the negative by a simple system incorporating a camera flash unit. The information is typed onto a card which slots into place in front of the flash gun . A high intensity flash briefly illuminates the card by transmission and the data is projected onto the image plane. The flash may be synchronised with the lens shutter opening or operated independently by switches on the control panel. The imaged area can be a section of a larger card which is filed with the photographic record, or can be a separate card which is subsequently thrown away. The data portion of a negative is not projected onto the image plane during identification, but may easily be read by viewing the negative over an illuminated panel.

k) Control panel

The manipulator, lamps, shutters and flash unit are all controlled from a single unit connected to the comparator by a flexible multicore cable.

1) Size

For stability the base of the comparator is a 1 cm thick aluminum plate about 120 x 75 cm in size (4 x 2½ ft). The maximum height is about 40 cm (1½ ft).

3. Paintings and Drawings

3.1 Recording the original

The most useful photograph of a painting for comparative purposes is unlikely to be that which would be chosen to illustrate the artistic merit of the work. For most paintings and drawings it is much easier to copy the general outlines than the fine detail, so that the latter is the type of information which should be recorded on the photograph. The most useful record will therefore be a photograph of an area of dimensions between 10 and 20 cm, chosen to give a detailed, high contrast image on the negative.

Thus, for paintings of dimensions up to about 20 cm the magnification may be chosen such that the whole of the painting is recorded on the negative; for larger paintings only part of the total area would normally be recorded. Although these figures are intended only as a rough guide and may be varied considerably for different paintings, it should be remembered that the smaller the area recorded the more important dimensional changes in the canvas and paint become. An operator using the comparator rapidly learns to recongnize the areas of a painting which are potentially most useful for identification and to estimate the optimum magnification for recording these areas.

Figures 2 and 3 illustrate these points. An oil painting of dimensions

25 x 35 cm is shown in Figure 2. Identification, as described in section 3.2, using negatives of this photograph was found to be a rather tedious procedure because of the lack of prominent, high contrast detail of sufficient size. Fig. 3 shows the central area of the painting imaged with a magnification of about 0.5. The crack is very prominent and identification using the corresponding negatives was rapid and easy.

In recording drawings and manuscripts more importance must be attached to recording the finest detail since it is relatively much easier to copy these works to a moderate degree of accuracy. Equally, however, the inherent sensitivity of the identification process is considerably increased for drawings and manuscripts, firstly because a sharp, high contrast image is much easier to obtain, and secondly because the dimensional stability of these works should be much greater than that for oil paintings. There will also be other works, paintings in water-colours for example, which fall into a category intermediate between drawings and oil paintings.

Having chosen the area to be photographed, the other important consideration is the form of illumination to be used. Most works would be positioned within about 50 cm of the imaging lens, so that the two ring, fluorescent tubes mounted concentrically about the lens axis would give sufficient, although not necessarily ideal, illumination. For drawings, manuscripts and some paintings this ring illumination is both adequate and convenient, giving an uniform diffuse illumination approximately normal to the plane of the work. However, many oil paintings are best photographed using oblique illumination to show up the cracks and relief of the painting and to give a generally higher contrast image. In all cases the approximate angle and configuration of the lighting for a given painting must be

Comparator Photographs of an Oil Painting for Identification Purposes.

Fig. 2 Comparator photograph of a 25 x 35 cm oil painting, together with data stripe.

Fig. 3 Comparator photograph of a detail of the painting in Figure 2, showing only the central crack network.

recorded.

During evaluation of the comparator it was not found necessary to use any colour filters when photographing paintings. However, with certain paintings the use of a colour filter may be advisable in order to enhance contrast and detail on the negative.

The format of the record to be filed is also shown in Figure 2. The photograph of the painting occupies a square of side 9 cm and relevant data is recorded to one side of this using the system described in section 2.2. The data recorded is not intended to be a comprehensive list of all relevant details and parameters, but rather essential information such as title, artist, and date, and a reference to filed data elsewhere. The actual record would be the negative of the photograph shown.

The production of the original record from a painting or some other work may thus be summarized as follows:

(1) The illumination and area to be photographed are selected and the lens in channel 2 (with prism removed) is positioned according to the magnification required.

(2) The painting is mounted normal to the optical axis on one of the special mounts available. The image may now be viewed on the diffusing screen at the image plane, and adjustments made if required.

(3) The painting is photographed through lens 2 and the data is recorded through lens 1 from a typed card.

(4) The photograph is developed and if the positive is satisfactory the negative is processed, dried and filed.

(5) All relevant parameters (lens position, illumination, etc.) are noted and filed with the reference number on the negative.

3.2 Identification

The first stage in the identification procedure is the repositioning of the painting, illumination and lens according to the parameters used when making the original record. By simultaneously viewing the painting through channel 2 (with the prism removed) and the record through channel 1, the magnification and positioning can be checked and adjusted if necessary. At this stage it should be possible to align the two images using the manipulator controls, and to detect any mismatch to a sensitivity in the order of millimeters. The comparison at this point is limited firstly because a positive painting image is being compared with a negative record image and secondly because the intensity of the painting image is necessarily rather low.

For a more accurate comparison the image of the painting is photographed by insertion of the Polaroid back at the image plane. After processing the negative is positioned in channel 2 with the prism replaced, so that this negative and the original negative are both displayed at the image plane. The two images may now be accurately compared in a number of ways.

Using the manipulator controls it should be possible to align the two images accurately over the whole field; the binocular attachment easily enables a sensitivity of tenths of millimeters to be achieved if required. For most complex

paintings alignment to the degree possible using the fresnel lens / diffusing screen combination (i.e. a sensitivity of better than 1 mm) would normally be sufficient. For drawings, manuscripts and geometrically simple paintings, use of the binocular attachment would normally be required.

Introduction of a green filter in one channel and a red filter in the other channel often facilitates this procedure. Before alignment the images combine to give green, red and orange areas randomly distributed over the field of view. On alignment a single sharp image is observed and the whole field becomes a uniform orange colour.

Alignment is also facilitated by changing the field of view rapidly from one negative to the other and looking for movement of image detail. A single switch on the control panel performs this function.

Identification may also be achieved using the split-field facility. The two images must first be aligned, although to a lesser degree of accuracy than that required above. A suitable vertical section is then chosen and the two negative masks advanced until they meet at the chosen line. The field of view now consists of negative 1 on one side and negative 2 on the other side, and using the fine controls for the masks a sharp dividing line can be obtained with no overlapping of images or masks. The manipulator can then be used to adjust negative 1 until all detail on the imaged negatives is aligned and continuous across the dividing line.

Examples illustrating the identification procedure are shown in Figure 4 - 7. In all cases the negatives compared are totally independent photographs of the same painting, in which the painting, illumination and lens have all been moved and repositioned between photographs. Fig. 4 shows a split field photograph of

a detail of the painting in Fig. 2; the two halves of the photograph (i.e. the original record and the negative to be identified) can be seen to line up accurately along the common edge. Fig. 5 shows a photograph of the same negatives when aligned (i.e. superimposed) and also the type of image viewed when the negatives are not properly aligned. Equivalent photographs for identification using the crack network of Fig. 3 are shown in Fig. 6 and 7.

The problems associated with copying a complex drawing or painting to a degree of similarity approaching the limit of detection of the optical comparator would be enormous. The problem of accurately reproducing a network of cracks or fine detail in an oil painting would in itself pose an insoluble problem. Thus provided a suitable record can be made of a painting or drawing, the comparator should prove a reliable and effective tool for detecting forgeries. One possible exception which should be mentioned would be the use of photographic techniques in copying the original. This can virtually be ruled out for paintings, but is a possibility for drawings and manuscripts. The comparator has, however, been used for the comparison of a real bank note and a forged note (identical to an untrained eye) produced by photo-techniques, and a difference was immediately obvious in the resolution and quality of the fine detail on the notes.

An important consideration, especially for paintings, is the stability of the work after the original record has been made. New paintings can change considerably during the first 100 years, and even older paintings can undergo appreciable dimensional changes if ill-treated or not kept in a suitable environment. Effects may be minimized by always recording the paintings in the same conditions of temperature and humidity, and allowing sufficient time for adjust-

Identification of Paintings.

Fig. 4 Split field photograph of detail from an oil painting.

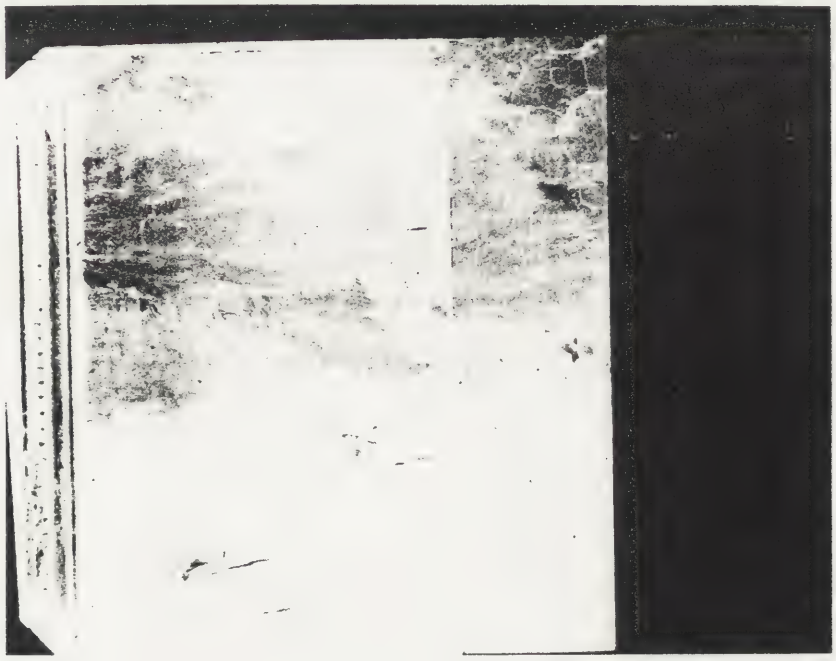
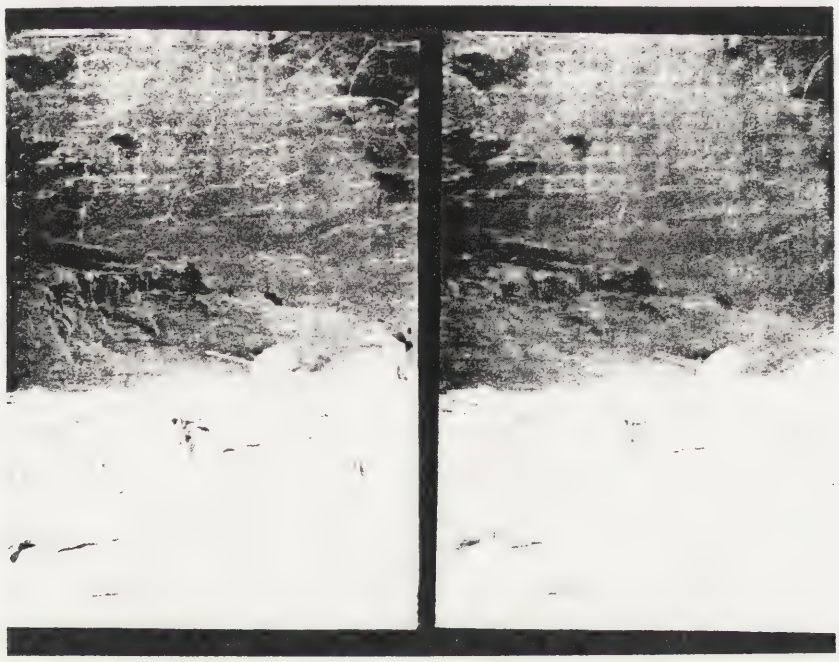


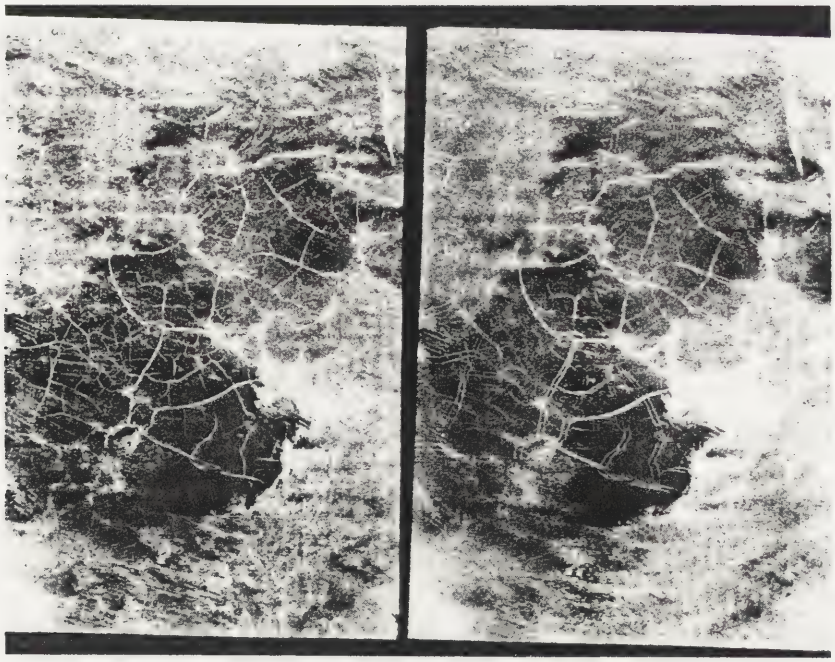
Fig. 5 Aligned and misaligned detail.



Identification of Paintings.

Fig. 6 Split field photograph of a crack network.

Fig. 7 Aligned and misaligned crack network.



ment to these conditions. It would probably be advisable, especially for new paintings, to set a maximum time limit for the intervals between photographing a painting, either for record or identification purposes. Usually any changes will be systematic in nature, and the comparator operator should have little difficulty in deciding whether observed changes can reasonably be explained by ageing effects. Obviously, in the event of any restoration work the painting would have to be identified before restoration and a new record made immediately afterwards.

4. Solid Objects

4.1 Recording the original

The fundamental difference between the identification of solid objects and that of essentially two-dimensional objects such as paintings is the intorduction of a new parameter in the positioning the object - namely the orientation. This will normally reduce to a rotation about a vertical axis, since most objects have a natural base. In choosing the area to be photographed, consideration should thus be given to the ease of repositioning during identification. With this in mind, the guidelines given in section 3.1 for recording paintings also apply to solid objects; in general a photograph of an area of detail of an object is more useful than one showing the general outline.

The limitations on objects which can be identified using the comparator arise mainly from the problems in obtaining a high contrast, good definition negative. This becomes more difficult when dealing with transparent glassware and highly polished surfaces. With such objects the exact positioning and type of lighting

can play an important part in obtaining a suitable negative. Diffusely reflecting objects made from metal, wood, stone and other such materials should present few problems. For any object, various orientations and types of illumination can be tried and photographed to determine which is the most suitable for identification purposes.

The smallest objects which could be treated with the comparator described here would have dimensions of a few centimeters. Possible adaptation to treat smaller objects would involve using a shorter focal length lens in channel 2 and special object mounts and illumination. At the other extreme, since only part of an object need be photographed, the maximum size is limited only by the ability to mount and adjust the orientation and position of the object without undue difficulty.

Thus it should be possible to make a suitable record of most solid objects, although there may be cases in which a negative of satisfactory contrast and definition cannot be obtained. It must be left to the operator to decide whether this is the case for a given object, and if necessary to make two negatives for immediate comparison to determine their suitability.

4.2 Identification

The illumination, lens position and approximate object position must first be reset using the parameters recorded when making the original record. The record in channel 1 and the live object in channel 2 may now be viewed simultaneously, enabling the orientation of the object to be adjusted until the views seen through channels 1 and 2 are identical. This step in the identification procedure is far more important for solid objects than for paintings where it

is only required that the plane of the painting is approximately normal to the optical axis. With some objects the comparison of a positive object image and a negative record image has proved difficult, and in such cases the record may be converted to a positive transparency by photographing it through channel 1. When satisfied that the orientation and positioning of the object are correct, the image is photographed; the processed negative is then positioned in channel 2 for comparison with the original record.

With certain reservations, section 3.2 is again relevant to the comparison of negatives of solid objects. If only a small area of detail has been recorded then the comparison is identical to that for two-dimensional objects such as paintings, and is by far the most satisfactory from an identification standpoint. The comparison of relief or outline as reproduced on the negatives is a more difficult procedure and one which is strongly dependent upon accurate repositioning of illumination and object orientation when making the second negative.

This point is illustrated by the comparison of the opposite faces of an opal glass (Figure 8). If the hand-painted flowers were absent a reliable comparison would be extremely difficult. The remaining detail on each face is of very low contrast and obviously highly dependent upon the illumination; the outline is equally sensitive to the orientation of the glass. However, a straightforward comparison of the centre hand-painted flowers, shown enlarged in Figure 9, clearly shows considerable differences. With the exception of negatives showing very high contrast detail, a split field type comparison is more useful here than one involving superposition of the two images. Fig. 11 shows a split field photograph of the two hand-carved deer shown in Fig. 10. With the upper and

lower outline matched at the split, the differences show up as a mismatch of intermediate detail. Clearly the differences here are relatively large, but the figure illustrates the general use of a split field to detect mismatch in two negatives.

In some instances the comparison of positive images was found preferable to using negative images. As pointed out above, this is readily achieved by photographing each negative through the same channel with unit magnification, and using the resulting positive transparencies.

Of the materials which would normally be encountered, wood and soft metals are probably the most susceptible to dimensional changes resulting from wear and ageing. As with paintings, the operator must decide whether any observed changes could reasonably be explained by these effects. Materials such as glass, pottery and ceramics, stone and hard metals could be expected to remain relatively stable over a period of time.

Providing a suitable record can be made, the difficulty in copying a sculpture or some other solid object to a degree of accuracy which would be accepted by the comparator is again extreme. Any technique involving hand carving would not reproduce the fine detail sufficiently accurately to escape detection. For metal objects a technique involving making a mould from the original and recasting an accurate copy might be a possibility, but again the accurate reproduction of the fine detail would be extremely difficult. Thus the overall conclusion is that reliable identification of solid objects is possible using the comparator, with the reservation that, as with paintings, the object must be compatible with the production of a suitable negative record.

Identification of Solid Objects.

Fig. 8 Opposite sides of an opal glass.

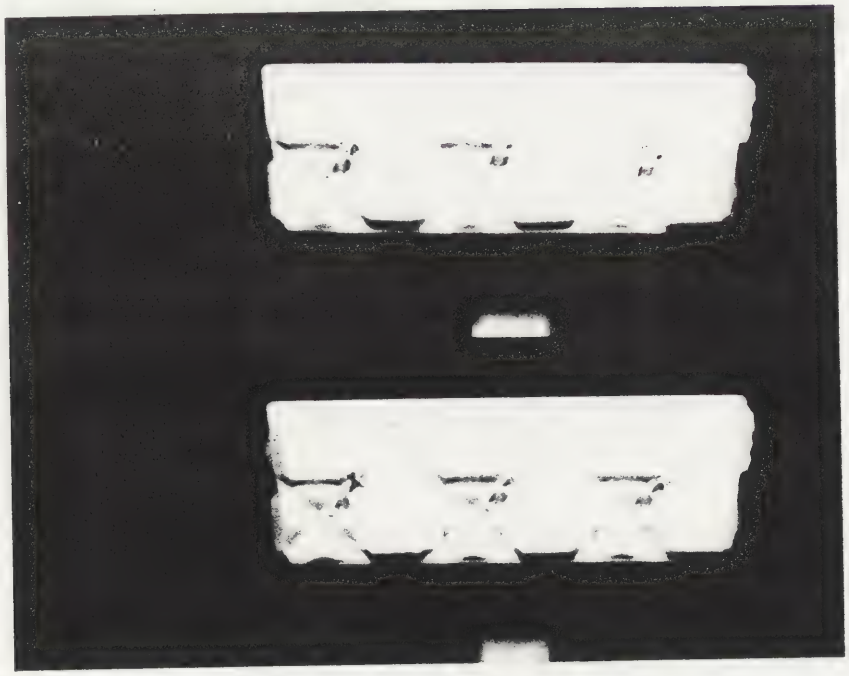
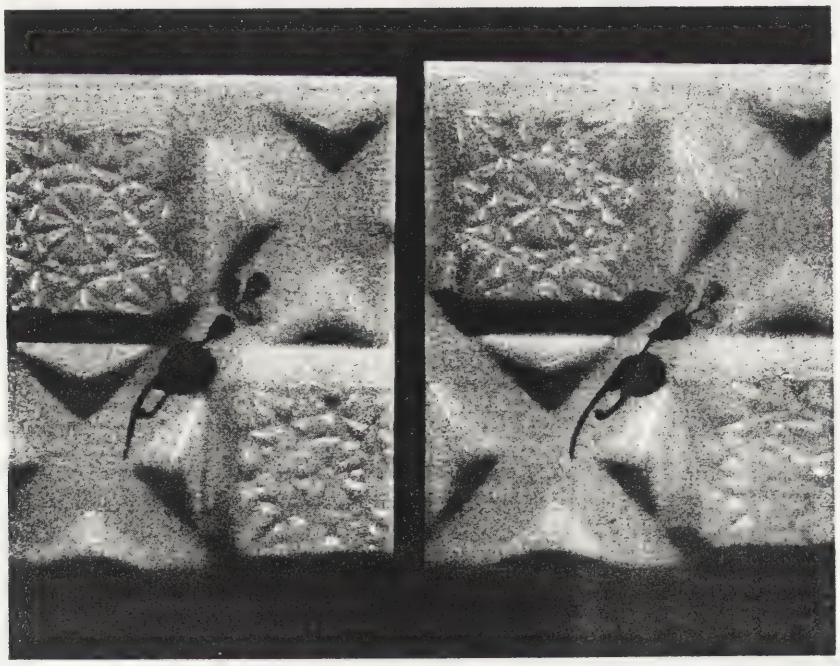


Fig. 9 Comparison of enlarged detail from Fig. 8.



Identification of Solid Objects.

Fig. 10 Two similar hand-carved deer.

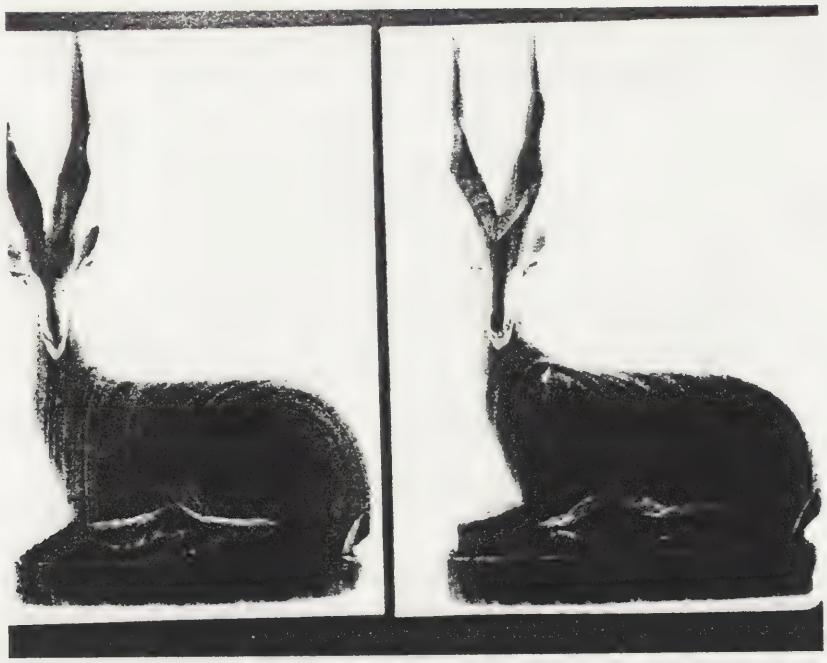
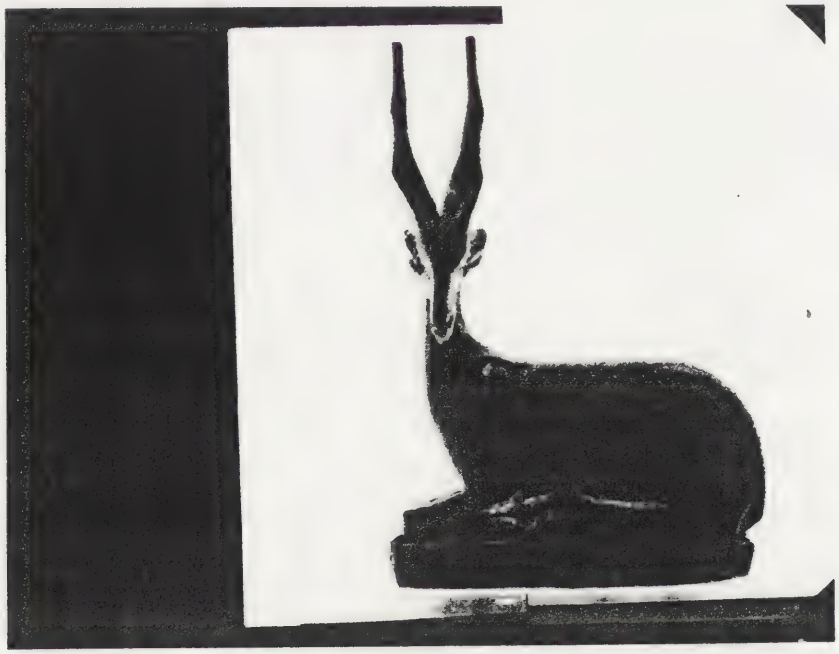


Fig. 11 Split field photograph showing differences between the deer.



4.3 Objects in situ

The optical comparator described in section 2 is not designed to be portable; it is intended that the works of art are brought to the comparator for recording and for identification. However, it is conceivable that the need may arise to treat some objects in situ, either because they are too large or too heavy to be easily transported, or because of problems arising from transportation of valuable works. This section deals briefly with a possible means of treating such objects.

The main requirement is a means of ensuring that photographs taken for identification purposes record the same area and orientation of an object as that chosen when making the original record. A modified press camera could provide a simpler and cheaper means of achieving this than any attempt to reduce the whole comparator to a portable unit.

Figure 12 shows schematically a possible camera modification based upon the image combining principle of the comparator. The object is imaged by lens 1 onto the film through a 50 % transmitting mirror which also reflects an image onto the viewing screen (fresnel lens and diffusing screen combination). The original record is mounted in a simple x,y movement in its own plane, illuminated through a diffuser, and imaged with unit magnification onto the viewing screen by lens 2. When photographing the object, the record negative and the diffusing screen must be masked off. The procedure for making the original record and the first stage in identification is then completely analogous to that using the comparator, and the two negatives would subsequently be accurately compared using the comparator itself. Either 35 mm film or Polaroid film could be used - the 35 mm system would enable a much more compact film holder to be used, but would require enlargement for use in the comparator and would not allow the rapid assessment of photographs

POSSIBLE CAMERA MODIFICATION FOR PHOTOGRAPHING OBJECTS IN SITU

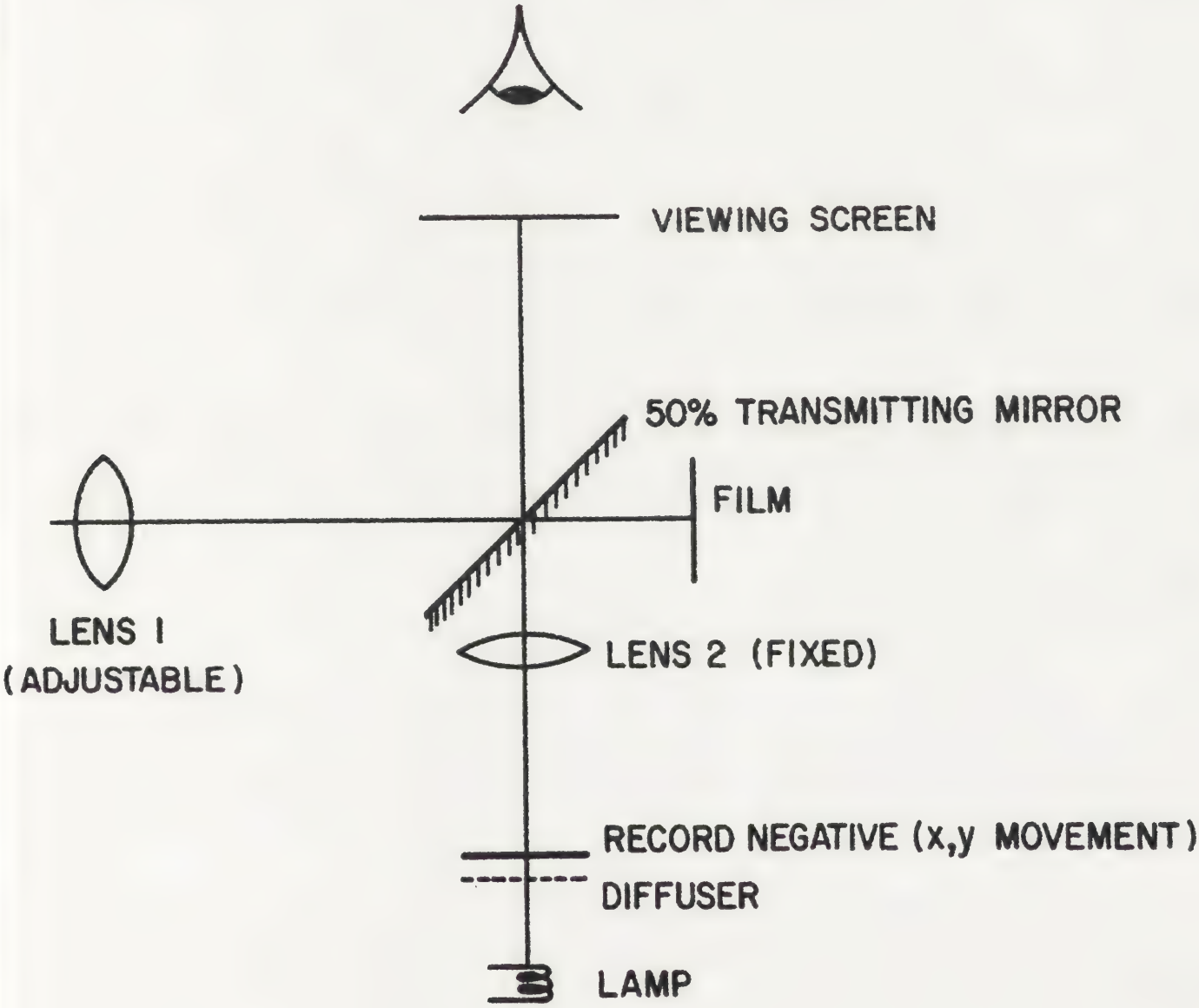


Fig. 12

which is possible with the Polaroid system. Stable positioning could be achieved using some form of tripod mount. Other considerations for taking negatives for the original record and for identification are as described for the comparator. Parameters such as lens setting, illumination configuration and possibly the lens-object distance must be recorded. The unit simply provides a means of separating the photographic and comparative functions of the comparator in order to reduce the size of the component which must be portable.

5. Conclusion

The optical comparator described in section 2 can be used to treat most classes of works of art which are likely to be encountered. The sensitivity is certainly adequate for reliable identification, and the extreme difficulty of making a dimensionally accurate copy of most works means that the possibility of accepting a forgery is very low. Instances in which a deliberate copy of a work has been sufficiently similar to prevent distinction at even a casual glance of the original and the copy together are extremely rare, if not unknown. Thus positive identification can reasonably be accepted as final; on the other hand rejection should not immediately be taken as definite proof of a forgery, but should be carefully considered in the light of the differences between record and object, intermediate treatment of the work, and any other information available.

The flexibility in use of the comparator is achieved by placing more emphasis on the role of the operator. Firstly, he must decide which particular aspect of a given work should be recorded and in certain difficult cases, mainly with solid objects, whether or not a suitable record can in fact be made. Secondly, in the identification stage he must be able, if necessary, to differentiate between changes resulting from ageing and wear of a genuine work and those which would arise from a forgery. In general this should not present any difficulty to an operator with some experience of the comparator and its use. If required, permanent evidence of identification or rejection can be obtained in the form of a photograph showing some comparison of the work and the original record.

The optical comparator is thus considered to be a satisfactory instrument for the recording and identification of works of art. Ideally it is most suited

for application to works such as paintings and drawings, but its application can also be satisfactorily extended to most solid objects. The prototype comparator which has been constructed and described in this report can be used as the basis for the design and construction of any further units which may be required.

The International Council of Museums
Committee for Conservation

Conseil International des Musées
Comité pour la Conservation

Madrid: October 2-8, 1972

Yu. I. Grenberg, All-Union Central Scientific Research Laboratory for Conservation and Restoration of Museum Artistic Works (WCNILKR), Moscow, USSR.

SOME PROBLEMS OF ELABORATION OF MUSEUM DOCUMENTATION FOR INFORMATION SERVICE

This report tries to elucidate some principles which in the author's opinion must be assumed as a base for the creation of a museum information system. The author dwells on an analysis of a subject index demonstrating its possibilities but prefers the system of a feature cards index system as one that most fully meets demands of a now-a-day museum work. This report stresses a necessity of creating a national scale standard for a museum index that can be considered as a step towards the creation of an international museum index.

As the art museums grow and the quantity of their objects enlarges the difficulty in obtaining of the information on each particular question in which an investigator is interested increases as well. The necessity of an efficient method of obtaining such information can hardly be overstressed if a museum is to serve its functions not only in collecting and storing of works of art. Museum claiming to be a scientific institution can neither develop itself nor give any help to others. Therefore the problem of the creation of documentation that would be effective in museum conditions for a long time preoccupied progressive-minded museum specialists (1).

The oldest method for the systematisation of data about museum objects is the compilation of various subject-cards that is the classification of items according to those or other characteristics. But in the majority of countries there was never a common principle of such systematization.

During the last 30-40 years some improvements of this traditional system were suggested.

In 1935 special committee that was appointed by the American Museums Association worked out a standard for the description of paintings in American museums (2).

Then in 1936 after a prolonged discussion the International Commission of Painting Experts accepted a suggestion on the description of works of art(3).

For the pictures of the Louvre collection detailed dossiers were established in 1936. The cards of different colours and provided with a photograph contain "absolutely all information that can be collected" about a picture(4).

In 1964 the Documentation Centre of ICOM submitted its report devoted to the study of normalization of museum catalogues that stressed the necessity of immediate beginning of the compiling of technical dossiers(5).

A year later the President of the Museum Association, Mr. Norman Cook, wrote in connection with a publication of a concise commentary to the above mentioned report: "I would like to see ICOM examine new ideas, such as the potential uses of computers for the cataloguing of collections... There is no doubt in my mind that museums could use computers in some way, but since few of us are trained in the science of cybernetics, what is needed is a working party, at a high level, to explore this new field for us and I would suggest that some central body such as ICOM could well sponsor such a study"(6).

All that was done up to date was summed up in a special issue of "Museum"(7).

After all at the meeting of the ICOM Committee for Conservation (Amsterdam, September 1969) a working party for documentation was established. Based on the program that will be set forth below, this party must submit its suggestions on the matter to a reccurent meeting of the Committee.

The party includes two coordinators: H. Barker (U.K., the British Museum) and Yu. Grenberg (USSR, WCNILKR) (8). The responsibility of the former is to work out the suggestion for documentation principles to use in archaeological museums(9), that of the latter to suggest such principles for easel painting.

Demands to be met by documentation of a now-a-days museum were formulated in the working program of the Committee as follows:

1. To lay down standards for documentation.
2. To investigate and recommend a simple and economically suitable method for small as well as large museums and galleries.
3. To investigate and recommend methods by which these systems can be integrated into larger national and international systems.

Proceeding from this program the author of this report first of all wanted to examine some information retrieval system that was the most acceptable from his point of view for museum use and to suggest his opinion about the ways and methods of their introduction into art museums.

1. Some general observations on the information system.

At present it becomes more and more evident that ways to the most efficient receiving of information are first of all the creation of a national standard for all fixed museum collections(10,11). The elaboration of such standard (classification

of characters) is to be the first step to the creation of a national museum index. Hence it is logical to examine a problem of storing and distribution of information that is to choose one or another information system.

Now-a-day a great number of different systems have been worked out and function and one must choose among them the one that is most acceptable to the museum specificity.

The information systems are not an absolute innovation. Conditions in which human activities (including a museum work) run always called for collecting, storing, retrieval and distributing of information. The traditional information systems include the most widely used subject index when all considered characteristics that are necessary for information storing are recorded on one card (similar to that in a catalogue). This kind of systematization is quite acceptable but the retrieval of information on the particular item is rather time-consuming. Let us suppose that to examine or to organize an exhibition one must find out in the large museum collection all objects of a certain genre or painted on a definite subject. To do this one must look through bulky catalogues of these collections and card-files containing some thousands of cards. The same problem arises when one needs to obtain an answer on any technological question. For instance to reveal what pictures from the museum collection are painted on metal panels it is necessary to look through all the catalogues or all card-files (if they contain such information) to be sure that a single picture is not missed.

In other words if the answer to any, even the most simple, question concerning a large museum collection is possible then it takes a lot of time. At the same time there are scores of questions urgent for a museum daily practice or for the co-operative institutions to be quickly and rather fully answered. Needless to say that as the matter becomes much more complex an answer to it will entail such great difficulties that it verges on the impossible to obtain it. Using a card-index one must make scores and hundreds of cards answering any possible question.

ow can the matter be settled?

here is another type of information system based not on a subject-
ndex but on a feature index. In such a system each card is a
ecord of certain features, that is all objects to have such a
eature are fixed on the same card.

n these conditions the retrieval and distribution of information
re quite simple: one must only pull out from a card-file the
ard that characterizes a certain feature of the object. The
reation of such a card-file enables one to disintegrate any of
omplex matters into the components, each of which would be
ecorded on a separate card and after choosing needed cards one
ould sum up their data and give a proper answer.

ow is it handled in practice?

t present the cybernetics offer different levels of mechanization
or the information-retrieval processes from electronic-logic
achines to manual handled punch cards. Unfortunately these
ossibilities either are not used at all or are used on an
xtremely limited scale. As a rule the majority of museum
orkers does not known about up to date techniques and methods
or the treatment of information. At the same time it must be
oted that obtainal of information is limited not only with
ndividual needs of separate investigators but it chantes from
personal problem into a social one connected with proper
unctioning of state collections that is their storing, catal-
guing, restoration and whole complex of researches in the field
f art history, including attribution and scientific examination.

here are some aspects that must be necessarily taken into cons-
deration when one chooses one or another information system.
nformation systems strongly differ one from another not only
n methods of storing and retrieval of information but for
nstance, in quantity of collected information, degree of distr-
bution speed and other characteristics. However, in any case
o fulfil the functions of collecting, storing, handling and
istribution of information any system must carry out several
perations.

rst of all it is necessary to select the stuff to be taken for oring, that is features or properties of works of art. For is aim all information which can be received or which is worth ing collected must be strictly analyzed to evaluate its content. ery work of art including a picture can be presented as a rtain number of objective features to use which one can describe concrete object. The evident idea of feature may be reduced to e following: an objective feature is a certain qualitative prop- ty of an object, which is fixed as single-valued and unchangable.

ch fact which comes into storing must be therefore treated in ch a way that it can be used in the future, that is that it can easily retrieved between others. This is called the creation retrieval image.

he documents and retrieval images are recorded on established nformation system vehicles (i.e. on cards), that is the formation nd the record of information.

he information storing together with its retrieval images is the the next stage.

ll these processes result in a certain information stock whose im is to supply a user.

he final stage is treatment of inquiries, that is reducing them form used in a given information system and distribution of nformation.

reation of any information system, its introduction and exploit- tion are connected with expenditures of material values and killed labour. Therefore before choosing one or another system t is necessary to outline the range of problems, to determine lements of the information process and its quantitative and ualitative conditions. Studying problems which must be decided ith this information system one must remember that such a system s a part of the information service and thus its introduction ust be proved in its use, output, and economy. In other words he system must meet the aims of its introduction.

he sphere of application of a system first of all is determine' y its users, hence the creation of the system is impossible ithout knowledge of their interests or without practical study f the range of the problems that they decide. Since, as the ystem will be exploited the sphere of its use will be changed, ne must take into consideration changing of information users. t is inevitable since users will gradually accustom themselves o the system and begin to forget traditional methods of inform- tion handling. Even the fact of introduction (if the system is fficient) inevitably affects users on the staff. Besides this t is impossible to take into account all individual needs though one can meet them very closely). A content of retrieval an (and will be) changed due to the level of science. For nstance, up to recent times presence of white lead indicated othing to the examinator of a given picture. Since this igment is used in painting from the hoary antiquity up to our ays and is present almost in every piece of old painting it as no meaning to make a card with a feature of "picture cont- ining white lead"! But the modern physico-chemical methods f examination made it possible to obtain more detailed charact- ristics of this pigment, its composition and structure. These eatures (for instance proportion of copper and silver impurities) llow to make conclusion about the time and place of pigment anufacturing that is to help for aims of art history. Thus it ppears a necessity in a card recording pictures containing hite lead with that or other properties. As to the productivity f a system it is determined by a reasonable proportion of econ- nical and technical possibilities of users needs.

system used for museum information has no additional speed of peration. Probably in the near future it will be unprofitable o introduce an automatic or even mechanised system.

hat is to be made for to find out necessary information?

he efficiency of a retrieval is determined first of all by a uantity of items among which the one that is searched for (to eveal all the needed items in a small museum is easier than in large one). Besides this, it is useless to search for an tem where it obviously does not exist (for instance it is useless

to search for white zinc among the pictures of the XVI century). Thus the first stage of retrieval reduces to elimination of all items that cannot be sought for. Let us try to mark all the items and to exclude from our retrieval those that have corresponding marks. For "marks" one uses certain features and properties of pictures. For instance a portrait, a female portrait, a twin portrait, the French school, XVIII century, a canvas, a panel, a painting on copper and so on, all these are "marks" or "features" for the retrieval of information. Hence if all paintings are divided according to their features into genres at a level of "portraits", one must exclude all cards that are marked differently, if classification is driven into "female portraits" one must retain only the cards with this feature and so on. Recording of features (though they are very different) creates a basis of retrieval or rather, a basis of an information system that gives a prompt and possibly completed answer free of an informational noise(+).

Thus the first step that makes a retrieval possible is reducing the items among which there is the one sought for (excluding, of course, those that are absolutely impossible).

The next step is to search among the remaining items, if there are not many of them. It is easier to find a portrait of two women among the group of "portraits" and still easier among "female portraits" or "double portraits" (the last two cases will be characterized with a superfluous information, the first of single female portraits, and the second of male pairs, the portraits of a man and a woman and other).

(+)In information theory noise is superfluous information.

Punched Cards

hat can be suggested for solution of the problem of creating of rofitable and practically available for any museum, restoratio: orkshop and research laboratory information system? An answer s given in the title of this section and at present there is no ther. This is punched cards(9-14).

echnically the information system ought to be realized in a lass of hand operated systems whose technical part only stores nformation on punched cards while all processes of system unctioning are performed by hand(15).

Edge punched cards

he two information systems examined above, item index and feature ndex, are corresponded with two types of punched cards.

n every catalogue that used punched cards the holes in a card are nothing but a coded description of a museum object or it eatures. In the same time each hole is equally accessible, hat is any feature of the item can be easily detected.

he item index is corresponded to edge punched cards. They are standard size rectangular cards of dense paper surrounded with one or two rows of holes.

Having numbered all outward holes of a punched card one labeles with the same numbers the different features of a work of art. Thus each position of the feature index corresponds with one definite hole on a punched card and each hole corresponds to one definite position in the indes (Fig. 1).

If there are not many features that must be searched for they can be recorded on a card itself without any coding, that makes operating considerably easier but limits the scope of storing information (Fig. 2,3).

s we discuss an item-index each punched card represents features f only one certain item. Therefore general data on a given work f art that are not the aim of retrieval are to be recorded on a orresponding punched card in the usual uncoded way.

or instance: name of painter,
title of the work of art,
date,
location of the work of art,
other information of uncoded record that must not be searched +).

s the thickness of a punched card has no importance it can be rovided with a glued photo of the corresponding work of art.

ll other data is coded according to an accepted code.

hen the code is made the peculiarities of each work of art are ixed by means of notching outward a corresponding hole. Let us ssume that linen support is coded with number 2, a glue ground (gesso) with number 4, oil medium with 9, ochre with 12, relining ith 14, and strengthening of ground with 16. Then to record for nstance that a given portrait is painted on canvas with gesso in il and that there is ochre in the complex of pigments one must unch outward the holes 2, 4, 9 and 12 to record information on restoration that is a relining and strengthening of the ground he holes 14 and 16 are notched out.

+) If any of the listed features can be searched (for instance subject, date, artist, and so on) all of them are to be coded on common ground.

Using such a system one makes as many cards as paintings that he wants to include in a given information system +). Let us suggest that in a system that contains not only technical and restorational data but also information on subjects and dates it is necessary to find out the portraits of men painted in the first quarter of the XVIII century. Let us assume that according to accepted code mentioned features correspond to holes 30 and 48.

To find out the portrait with these features one takes a sorting needle (a thin steel rod with a handle) and puts it into a leveled pack of cards in hole 30. It is evident that all cards whose hole 30 was notched outward would fall out of the pack and we shall have all male portraits. Having gathered these cards and leveled them again, we must put the needle into the hole number 48. The cards that would fall out of the pack at this time are all the male portraits painted in the first quarter of the XVIII century. Let us assume that then we wish to know which of them are painted on fine linen canvas with oil ground. Operating in a similar manner we select among all the male portraits of the first quarter of the XVIII century only those which have the pointed features. If not only one sorting needle but several of of them are used they can be put into all needed holes situated on one side of cards simultaneously. Thus a number of retrieval operations will be reduced, information noises will be eliminated (or lessened) and hence the necessary information will be obtained more quickly.

Using such a system and searching for one feature only one can treat manually up to 500 punched cards and if several features are searched for simultaneously it takes 3-4 minutes, that is

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+) The order of cards in a card pack has no importance. Cards have no fixed location in an item index that excludes their losses with disarrangement and makes arranging needless.

during this time the information in which we are interested can be practically obtained on any picture from the collection of a large museum.

One can see that this system is the best for the museum cataloguing: it is simple, not expensive, can be easily uniformed and available both for a small museum and for a large one. But it has one considerable shortcoming, that is that punched cards which are filled on a base of an item-index have an information scope limited with a number of holes punched in them +). For instance the subject. A retrieval system can be limited with a list of genres: portrait, still life, historical painting, landscape and so on. But one can accept a more detailed division If on the inquiry about a double female portrait a system presents information about all portraits in general, though it facilitates a retrieval it gives a lot of superfluous data. Therefore it is expedient not only to code subjects but to detail such coding.

For instance "portrait" may be subdivided:
male,
female,
of children,
double,
of a group.

+)Scope of information fixed on edge-punched cards can be considerably enlarged if described system of direct coding in which each feature is corresponded to a certain hole would be substituted with a system of complex coding. With complex coding a card with 30 holes can be used not for 30 numbers but for any three digit number and with a code 1, 2, 4, 7 (see Fig.1a) on a card with double line punching one can record any three digit number using only 12 couples of holes. There are also other kinds of coding. One must however take into account that the simplier a key is the less mistakes to be made when the cards are punched and sorted.

The same can be said of the chronology too. Coding can include only the century of a painting's origin or divide each century into parts, into quarters for instance. The same equally applies to technological and restorational features. Therefore, despite the fact that edge-punched cards have a very important advantage to be recommended for museum use, they are rather a means for an individual museum research (that is when an investigator deals with not too many features) than for a museum in general. In the last case such punched-cards are unfit to use since they can not cover all necessary information. For instance in the Döerner Institution (Munich) only technical information on pictures covers 2500 features (12).

The superposition punched cards

Another type of punched-card can be used in an information-retrieval system. To this aim a punched card serves not for fixing of a picture but for recording of each separate feature on it. Thus the number of punched cards corresponds exactly to the number of features to be recorded, stored and easily achieved. The number of features to be selected and hence that of punched-cards can be constantly enlarged and does not involve any condition. In this case a certain limitation lies in the number of items which can be fixed on one punched-card. Therefore this type of punched-card corresponds to the information system based on a feature-index. A principle distinction of this system from the previous one is the fact that each punched-card stores similar features of different items and holes in these cards were made according to numbers of items, that have such features. The features-card differs from item punched cards with the fact that information scope fixed on them is practically unlimited. A system operated on this principle enables one not only to search a particular work of art, but makes it possible to achieve an additional information of archival (scientific) character.

Efficiency of such a system depends wholly on a proper selection of features. In this case such features as subject, date, material or structure of support, ground, paint-layer, kind of

estoration and so on are recorded on a punched card directly, hat is in uncoded text.

ow do such punched card records look in such an information system? For instance in a general list of all pictures stored in museum (or treated in a laboratory), a double male portrait f the 3rd quarter of the XVIII century that was painted on a eech panel, with gesso, in oil appears under number 518.

et us choose from the pack all punched cards under titles:

male portrait,
double portrait,
the 3rd quarter of the XVIII century,
beech panel,
gesso,
oil.

et us punch the hole N°. 518 on each of these 6 cards that would ean that the picture listed under number 518 has all these features, that is punching of the hole number 518 on a card labeled "beech panel" would mean that a portrait listed under number 518 s painted on a beech panel.

ach picture would be treated in the same way. As a result umbers of every picture that has certain features would be ecorded on each punched card.

ow the retrieval can be produced without any mechanization. To ind out a portrait that has listed features one must take the unched cards of male portrait, double portrait, the 3rd quarter f the XVIII century, beech panel, gesso, and oil, then place hem on the top of each other, the sequence is of no importance. ll these cards would have several holes (their number depends n the number of paintings that have given features). There ould be some male portraits, some double portraits (including female, children and other), some paintings on beech panel, a ot of items executed on gesso and in oil. But if in the museum ollection there is only one picture that has all the features n which we are interested, then having held up this stock of

cards to the light, one can see through the cards at the number 512 only. It may be that in the museum collection there is one analogious picture more. It would result in one through hole more.

Hence each feature card is used to collect all information about items that have certain features in one place. If it is necessary for a user to form an opinion about the evolution of male portraits in Europe, one needs only to take the card with the correspondent title. Numbers of all items in question, regardless of their authors and dates of completion, would be coded on it by means of holes. If we wish to limit their number with that of completion time, school, painting technique and other features it is enough to place the first card on top of a card (cards) with other features and have the needed answer. Such punched cards have different informational scopes (Fig. 4). The cards used in West Germany cover information about six thousand items (Fig. 5), those used by the British Museum cover ten thousand items. In addition number of works of art covered by such a system can be easily enlarged. For obtaining this aim it is enough only to make a parallel card stock. It the first one would store information on items from number 1 to 10000, then the second would cover museum objects from number 10001 to number 20000. To this aim it is enough to label the top edge of punched cards with index + 10000. Then adding to any found on a card number (for instance 3161) 10000 we would have the item in question, that is 13161.

It is necessary to take into consideration that every information system is as a rule in a certain connection with an information system of another kind. Therefore both item-index as well as feature-index do not exclude the presence in a museum of an inventory that is a book bounded and provided with seals which is an official document. It is because of that fact that this book cannot be used for collecting of all new data on the picture or for fixing of its shifts in a museum and so on.

The described information system does not exclude the use in a museum of conditional subject-cards. On the contrary using feature punched cards it is necessary to have a clear text card-file in which all museum objects would be ordered alphabetically.

Since one obtained answers in a form of a number it is necessary to use subject-card files to indentify these numbers with works of art +).

Whatever information system is chosen one must remember that any of them could distribute only that information which was inserted into it. Therefore the punched-cards in which the information is stored must correspond as close as possible to a field in which the system would be used in a museum and out of it.

+) In the given system all works of a single author would be recorded also on one card. In this case an author's name is one of the features. Thus having pulled out the card with title "Rubens Peter Paul (1577-1640)" one copies out all punched hole numbers and then finds them in the inventory. If only female portraits by Rubens are to be found one needs only place on the card "Rubens" the card "female portraits". Coincided holes would be just the needed subject of pictures found on the feature card.

3. National and International Standards

Selection of an information system does not mean that it could be immediately used. Introduction (insertion) of any system requires a preliminary preparation that is not only to acquire necessary equipment (punched-cards and boxes for them) but also to allot and to train personel that would handle the system, to fill cards, to punch them, that is to accumulate and record information, store it and distribute it to users. But it is not enough yet.

An information system based on feature-index requires that each item to be included in the system would have its own number. At the same time though in every museum there is an inventory and all museum objects have their inventory numbers, but in practice it is far from uniform. Besides consecutive continuous numeration there are sometimes numerations according to periods, separate years and so on. Often numeration has additional indices of departments, dates of acquisition, etc. All this is unfit to the given system. Therefore all museum objects must get either a new numeration that would exist in addition to a feature-index and must include museum inventory numbers corresponding to that being punched on cards.

The latter way would be probably the only acceptable one, especially for old museums. It would entail only additional labeling of works of art, but would entail no material expense and make it possible to insert a new information system.

The next stage that maybe is the most crucial, is the choice of features for which separate punched cards are to be used. The proper selection of features to be stored, their intercommunication and coordination is a guarantee of the system's fitness.

Of course every art museum, laboratory, restoration studio can have punched cards adjusted for its particular aims. However one must remember that a system called upon to supply must first of all accumulate information according to a standard list. Hence the problem of creation of a national standard arises.

"To-day with specialists in all fields making increasing demands for more detailed information from museum collections, - writes Lewis, - the inadequacy of existing records is becoming very apparent and understandably there has been agitation in more than one specialist field for a national index of museum specimens relating to a special subject. If however the museum profession is unable to meet these demands it will be faced with a number of separate specialist indexes which as self-contained units will perpetuate the fallacy of treating each subject in isolation..." (10).

Centralization of scientific documentation is a very important factor of examination of museum collections but its realisation is not a simple matter. Thus in Germany, for example, organizing of a Central Archive for accumulation of all scientific information was tried much more than once since 1900, but this aim has not been achieved up to date (16).

Creation of a national index has two aspects. There is a necessity in strictly thought out classification of feature on level of a national standard that would obligatory for all to use. This in its turn enables to create in future an united centre for storing of such documentation which can use not manual but mechanized proceeding and dissemination of information. Advantages of united national index given for museums are hardly to be overestimated.

It must be however remembered that fear of great volume of work can prevent insertion of this important undertaking. For this aim it is very important to make a proper classification that would be adjusted first of all to requirements of museums and thus stimulate the work in this direction.

It is not necessary to insert such a system of cataloguing by means of orders. It would be rather harmful than have any use. Perhaps it is also not necessary to use it for all collections of a museum simultaneously or to demand to fill all cards correspondingly to a given standard.

At the same time it is undoubtedly useful to pursue at first rather a state than an investigational aim.

A feature card information system meets all these requirements the most fully: it allows to insert those or other features step by step in every sequence and every quantity. The grade of detailization of analytical data to be inserted into card-files depends not only on a system in general but also on a list of the institutions that collect information as well as on any specific object (or it examination). Museums without analytical laboratories cannot produce punched cards on technological features of works of art. But if such examination has been made elsewhere and the museum has corresponding documentation it must fix this information in its information system.

At the same time it is important that all secondary information (on laboratory and restoration examinations) to be stored in the museum under the same number (or code) as the work of art to which it corresponds +).

If punched cards must be recorded stage by stage and at first stage such records may be minimal it is necessary from the very beginning to cover as many features as possible (of course their number will increase in the future).

+) For storing of data on analytical and restoration reports by means of punched cards the same requirements that are used for works of art must be observed. All reports must have ordinal numbers free of any index. All materials stored separately of reports (x-radiograms, cross sections, material relics) must have the same number.

Evidently it is the most useful to divide all features of works of art that are to be recorded into three parts according to their meaning:

a) art-historical,

b) technological,

c) restorational.

Each one of these parts is divided into sections in which feature punched cards are in alphabetical order.

Taking into consideration a number of factors:

1) that problems of museum documentation have assumed an international character,

2) that the idea to create the national index is accepted by experts of many states,

3) that punched-card storing systems are accepted to be the most reasonable for our times,

4) thatthe ICOM Committee for conservation acts as guarantee the author considers as reasonable to recommend the following.

The ICOM Committee for conservation will set up at the next meeting a working party to work out foundations for the classification of works of art features (for easel painting) and definitions of the minimum of features to be incorporated in an information-retrieval system. This list must be send to all prominent national centres (museums, art galleries, laboratories and institutions) to examine and discuss, after which it is to be returned to the working party with corresponding remarks. General conclusion of these materials is to be reported at the next session of the Committee. If it will be approved by the Committee it must be published in one of the ICOM publications and provide a foundation for working out of national standards. Working out such a classification it is necessary to course to take into account all used classifications (for instance that used in the Döerner Institute in Munich, in the British Museum and in other institutions that have great experience in this field).

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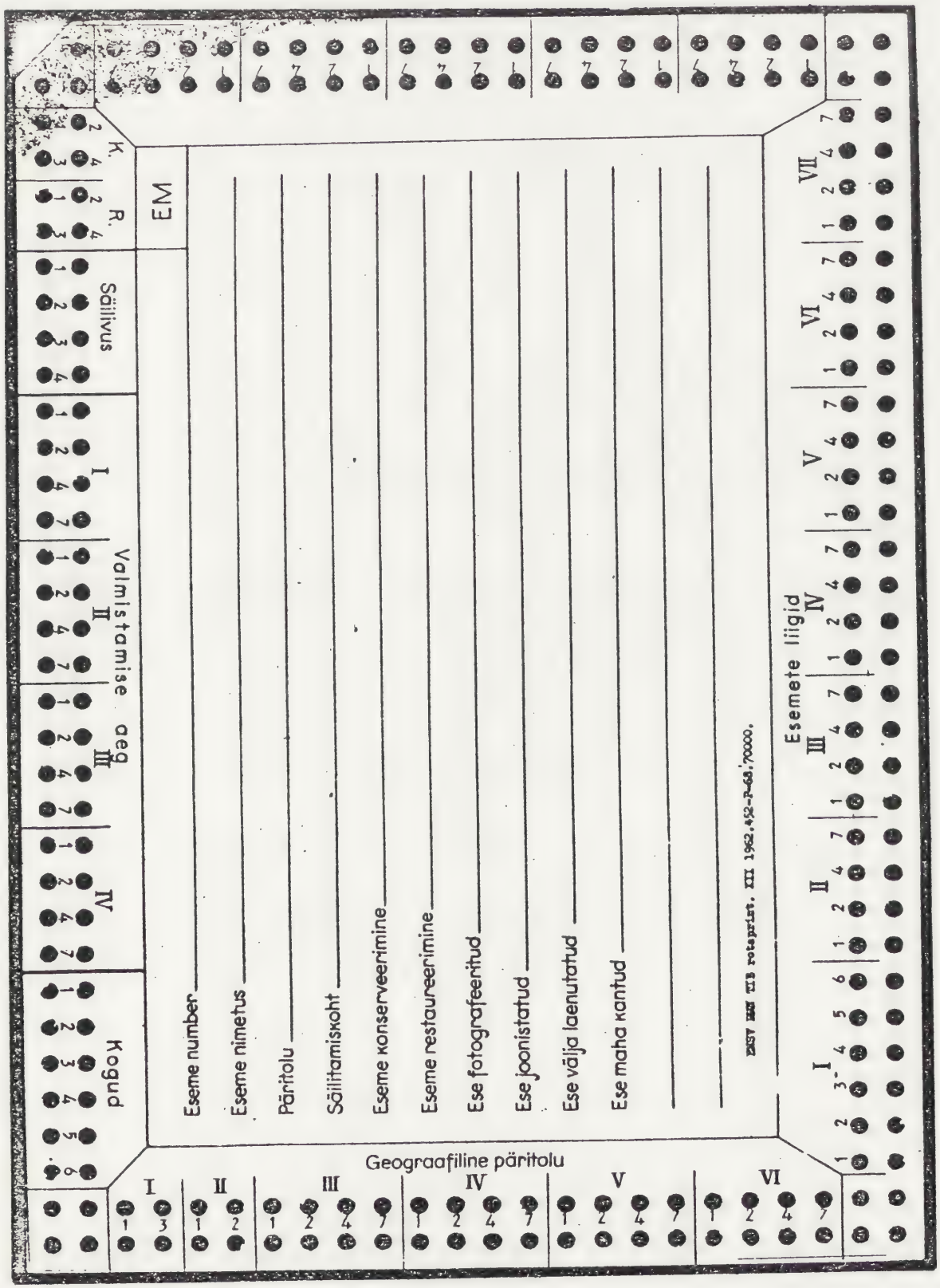

Fig.1.

A two-line edge punched-card coded in 1-2-4-7 key in order to enlarge the volume of information to be recorded. (The State Ethnographical Museum of the Estonean SSR). Size of a card is 207 x 147 mm; diameter of a hole is 3 mm.

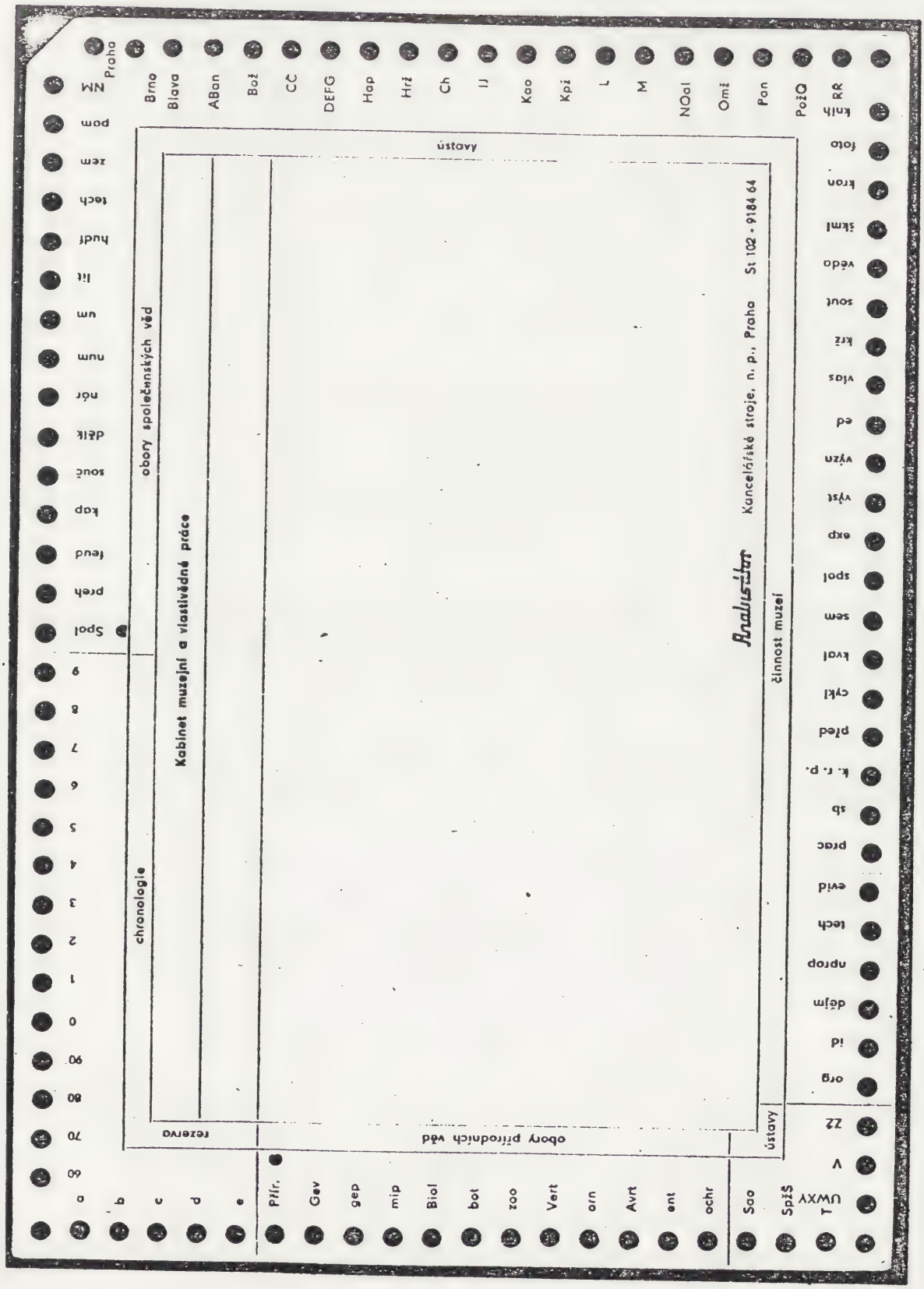

Fig.2.

A one-line edge-punched card coded in direct code in which each hole is corresponded with a definite feature marked on the card itself. (The cabinet of museum and locale lore studies. Prague). Size of a card is 210 x 148 mm; diameter of a hole is 3 mm.

13/2

Comité para la Conservación

LA INSTLACION DEL LABORATORIO DE CONSERVACION Y RESTAURACION DEL MUSEO NACIONAL DE BELLAS ARTES DE RIO DE JANEIRO - BRASIL

Comunicación a la 3ª Reunión Plenaria de la Conservación del INTERNATIONAL CONCIL OF MUSEUMS - ICOM. Madrid, 1972
Presentado en la sesión del grupo de trabajo de Formación y Entrenamiento.

Por SERGIO G. Lima
Conservador Responsable

S U M A R I O

INTRODUCTION

Nuestra participación en la 3ª Reunión Plenaria del Comité para la Conservación del International Institute for Conservation - ICOM es la oportunidad que se presenta para hacer una evaluación de lo que ha sido nuestra pequeña pero efectiva atuación en el trabajo de la Preservación de Bienes Culturales en nuestro pais desde el momento en que regresamos de nuestro entrenamiento en el Centro Latinoamericano de la UNESCO en Mexico, hasta el presente.

El "Compromiso de Brasilia"[1] asi como la "Conferencia de Salvador" en Bahia marcaban con enfasis la necesidad de poner en ejeción una politica nacional de preservación del patrimonio cultural brasileño. La urgencia de ejecución de un programa a largo plazo en el que se haria incluir ciertamente un inventario de nuestro acervo cultural. Es patente en aquellos documentos. Mas aún, esto es básico para la realización de un catalogo razonando de todo lo existente, asi como tambien las consecuentes medidas de órden prioritário de conservación.

Son estos encargos, todavia, de una complejidad muy grande. El elevado presupuesto requerido en la preservación de bienes culturales, hace que sea necesaria la participación no solamente de las autoridades gubernamentales, sino tambien de la ayuda efectiva de empresas privados. Si al primero le toca proporcionar recursos tecnicos, materiales y humanos, extremamente gravosos, al segundo se le pide una buena dosis de comprensión y de sensibilidad para con los motivos de nuestro enorgullecimiento nacional, imponiendole muchas sacrificios a los cuales no estan todavia preparados, principalmente cuando estos sacrificios se traducen en pérdidas de ganancias.

En este punto se hace necesaria la acción interdependente tanto por parte de la universidad, cuanto de los demás sectores cul

turales. Queremos con esto decir que las pesadas cargas que son impuestas para la preservación de estos valores culturales de la humanidad, necesitan que sean compensadas por su eficaz utilización.

Creemos que la universidad tiene un papel de importancia en esto. Es sabido que en su seno estan los factores capaces de poner nuestros valores culturales en punto de utilización. Tanto por su personal especializado, cuanto por sus instalaciones y equipos al servicio de un plantenamiento regular e sistematizado. Todavia falta mucho para que las universidades puedan trabajar, como es necesario, en nuestros valores culturales, ya que estan al servicio de las necesidades / básicas presididas por industria, el comercio y la asistencia social, quedando aquellos valores invariablemente por ultimo. Todo esto parecenos todavia más claro cuando pensamos en areas de proporciones continentales como la de Brasil. Sin embargo timidamente se da inicio al intercambio con la Universidad.

Una importante contribución es esperada de los museos, con su gradual transformación en instituciones modernas con programas encaminados a consiguir visitantes cada dia más interesadas. Pero aunque sean muchos los pasos que hemos dado en este sentido, hay mucho todavia que hacer en este sector, lo que presupone demasiado tiempo, lo suficiente para que la polilla, la acción actínica, los hongos y la polución hagan su trabajo inexorable.

Por eso he venido acá mucho más para escuchar que para hablar. Sin embargo creemos que tenemos algo que decirles en cuanto a la multiplicación de nuestra experiencia personal, la que nos ha sido proporcionada por el entrenamiento en la UNESCO. Sobre todo en lo que toca a la formación de criterios de personal, tenemos interés en cambiar observaciones y experiencias.

En esta breve comunicación por lo tanto, haremos un resumen historico del origen y naturaleza de la colección del Museu de Belas Artes do Rio de Janeiro, centro de nuestro trabajo y observaciones, lo que ha sido su conservación en su existencia de cerca de treinta y cinco años, personal encargado de la conservación y su grado de formación. Tambien las posibilidades actuales de profesionalizarse en Brasil y en este contexto, lo que significa la reciente creación del Laboratorio de Conservación en el Museu Nacional de Belas Artes, asi como observaciones acerca del plan de instalación, funcionamiento y resumen de actividad despues de los onze primeros meses de trabajo.

Esto es todo lo que traemos a esta honorable asemblea, no tanto por hacer una presencia, como para atraer la atención del examen y la crítica.

LA PINACOTECA NACIONAL

La venida de la corte con la familia imperial hacia el Brasil, a principios del siglo pasado, permitió que se crearan condiciones para la formación de los mícleos iniciales de dos de las principales colecciones de documentos tanto iconográficos, como bibliográficos, o sea el Museu Nacional de Belas Artes y la Biblioteca Nacional.

La creación de la Academia Imperial de Belas Artes despues "Escola Nacional de Belas Artes" de La Universidad Federal de Rio de Janeiro, ha permitido la formación de una colección de arte con origen en lo que constituyo el bagaje de la mision Artistica Francesa llegada a Rio de Janeiro en 1816. La primitiva colección fue graduativamente aumentada no solo con nuevas adquisiciones, donaciones e incorporaciones por efecto de los premio oficiales.

Con la organisación del museo más tarde, en 1937, se proporcionó un destino más adecuado a la colección, ya que no solamente era para un pequeño grupo de estudiantes, sino que se facilitó asi la visita a un numero mucho más amplio de personas interesadas. Con el tiempo, resultó que con el crecimiento gradual de la colección, el espacio arquitectural fue dismimuyendo, principalmente despues que las modernas técnicas museológicas pasaron a exigir un menor numero de piezas en las galerias y salas de exposición, llenando a su vez los depósitos de manera crítica.

LA ARQUITECTURA DEL MUSEU

Para que tengamos una mejor idea de lo que es la disposición de los espacios interiores del "Museu Nacional de Belas Artes", basta que miremos los esquemas representativos de los principales pisos (anexo 1). La edificación es desarrollada en la forma de plan central compuesta por galerias rectangulares articuladas por espacios cuadrados menores. Una parte tiene las soluciones de iluminación y de aeración resueltas naturalmente por el contacto libre con el exterior. La parte ubicada internamente +está pendiente de acondicionamiento y de su respectiva dotación de presupuesto, medida que ha sido propuesta por nosotros a la dirección, estando ya en curso los estudios para su instalación. Hay que aumentar la diversidad de materiales que integran los más variados objetos en los respectivos departamentos de pintura escultura, dibujo, grabado y artes ornamentales. En orden de incidencia, es mayor la presencia de materiales orgánicos; lienzo, papel, madera, cuero y marfil.

Los materiales petreos registran una gran incidencia principalmente en los objetos trabajados en creta, estudios, maquetas, originales.

Los metales están presentes en menor numero, esculturas en bronze, hierro y pequeños objetos en metales nobles.

Los materiales sintéticos empiezan a comparecer en las nuevas aquisiciones e incorporaciones debidas a los premios oficiales que por fuerza de dispositivo legal van a integrar la colección del museo y el patrimonio nacional.

+aquella esta dependente a condicionamento

1.2 - Histórico de la Conservación

La reglamentación interna de los Servicios del museo, incluye el departamento de restauración en su cuadro de personal técnico con un restaurador y ayudantes especializados.(5)

De lo que investigamos en la documentación existente, publicada en los boletines del "Museu Nacional de Belas Artes" y "Arquivos" de la "Escola Nacional de Belas Artes, nuestros primeros restauradores tuvieron su origen en la formación misma impartida en los cursos de arte de la referida escuela. Todavia hoy, es posible comprobar que son las escuelas oficiales de arte las que de alguna manera tienen a su cargo la información a nivel de complementación de los cursos regulares de arte, de técnicas de restauración, lo que excluye una habilitación profesional en este particular.

Creemos son las razones mencionadas las que han presidido la conservación de colecciones no solo del Museu de Belas Artes, sino de los demás museos en el teritório, de una forma empirica, lo que puede ser visto non solo de forma directa por una simple visita de los museos, sino tambien por la ausencia de toda documentación que atestigue lo contrario. Los boletines a los que hicimos alusión no dan más que noticias sin ninguna precisión a este respecto.

A juzgar por los "gabinetes" de restauración todavia existentes en algunos de nuestros museos, acreditamos que solo a partir de la iniciativa pionera de la Diretoria del Patrimonio Histórico e Artistico Nacional se ha intentado una nueva organización a nivel más actualizado de la conservación de bienes culturales en Brasil. (6)

Una solución de emergencia ha sido puesta en ejecución por la dirección del museo en los años de 1967 a 1969 con la oportuna contratación de los servicios técnicos de un restaurador solucionando una situación de orden critico, pero no en en definitiva del problema, ya que como es sabido, solamente un trabajo metódico y constante es capaz de producir resultados eficaces en la conservación de bienes culturales y es esto justamente lo que ahora intentamos hacer con la instalación del Laboratório de Conservaçao en el Museu Nacional de Belas Artes.

El problema de acondicionamiento de las colecciones de los museos brasileños con exclusión de unos cuantas excepciones a la regla, no tiene correspondencia con los adelantos a que ya llegamos en este particular. Es importante hacer notar que a las ya conocidas variaciones higrometricas producidas por efecto de un clima tropical se suman el alto grado de agentes de polución en la atmosfera de las grandes ciudades.

1.3 LA FORMACION DEL CONSERVADOR DE PATRIMONIO (RESTAURADOR)

De algun tiempo a esta parte, ha aumentado el interés por la profesión de restaurador, lo que es debido sin duda a la divulgación de los trabajos que durante más de cuatro lustros ha realizado el Instituto de Patrimonio Histórico e Artístico Nacional. Hay que destacar tambien la ayuda proporcionada por la UNESCO y demás organizaciones en forma de becas para que colegas nuestros se perfeccionen en los centros del exterior, principalmente en los de Madrid, Bruselas, Roma y Mexico.

Todavia una evaluación de los resultados esta por hacer. Por lo menos en lo que respecta a la plena actuación despues del regreso del becario al país de origen, que posibilidades de trabajo ha encontrado y cuales han sido sus principales dificultades, que por cierto las hay en gran numero. Muchas de estas cuestiones han sido ya abordadas en nuestros informes periódicos no solo a las instituciones que han proporcionado las becas, sino de igual modo a nuestras autoridades.

Nos ocurre hacer de pronto una sugerencia con respecto al mayor numero de oportunidades para nuevos entrenamientos de personal. Pero a nuestro entender esto solo no es suficiente.

vez en cuando, consideramos que en un intervalo de dos años.

Otro aspecto relevante es la presencia regular en Brasil de especialistas que por ejemplo de los que son enviados por la UNESCO a otros paises para impartir conferencias o cursos rapidos, como la unica forma capaz de ponernos al tanto de lo que se ha progresado en la conservación de bienes culturales además de la literatura especializada.

Reconocemos sin embargo que un trabajo basado en la noción de una estrecha colaboración es asimismo importante. Creemos que solamente la práctica continuada de multiples contactos es capaz de producir una verdadera confianza tanto de parte de aquellos que la necesitan, como de parte de aquellos a quiene cabe la responsabilidad de orientar la mejor solución posible.

En principio ofrece el Brasil algunas opciones de formación de restauradores, pero no todas al grado de nivel profesional. Regularmente, como hemos ya visto, en el ámbito de los cursos impartidos en las escuelas de Arte. Otros se han iniciado trabajando con algunos de los restauradores en actividad e integrado los cuadros de personal a disposición de los museos. Pero ninguno de los profesionales con quienes hemos tenido contacto tuvieron la oportunidad de una actualización de su experiencia. Hay que decir una palabra con respecto a la gran distancia que separa los pocos restauradores en actividad, en este inmenso pais. Al escribir estas lineas se nos ocurre la expresión de P. Coremans en su articulo para el numero XI de la Colección "Musées et Monuments" de la UNESCO; cuando hizo aquel ilustre técnico belga la referencia a la "torre de marfil" a que por las mas variadas razones se situa el profesional de la restauración y de la cual como en cualquier otra profesión, trae como resultado su proprio atrofiamento.

Muchos han sido los cursos de diferentes grados, en su mayoria de pura información, que han sido impartidos no solo en el ámbito de las escuelas de arte,(8) sino tambien en los museos y universidades. El primer curso a nivel de pograduación y de finalidad eminentemente profesional, fue el que tuvo lugar en la Escuela de Museologia en el año de 1968.(9) En el, junto con una información teórica, se ha proporcionado un tiempo equivalente a 4/5 de entrenamiento en el taller, para alumnos seleccionados entre los cursos de arte, museologia y arquitectura. Algunos de los restauradores que actualmente trabajan en diferentes regiones del pais y hasta de paises vecinos, han tenido su formación

Nacional , bajo la orientación del restaurador E. Motta.(6)

Actualmente nos incumbe presentar a la dirección del Instituto de Bellas Artes de la Secretaria de Educación y Cultura del Estado de Guanabara - Rio de Janeiro - un proyecto de un curso regular a nivel tecnico profesional de Conservador de Bienes Culturales en el cual tenemos la colaboración del Prof. Almir Paredes que acaba de regresar despues de haber cumplido un programa de perfeccionamiento en el Instituto Dr. José de Figueiredo en Lisboa, centro en que estuvimos trabajando también en nuestra primera oportunidad de especialización fuera del pais. El referido curso en estudio, está estructurado en un sistema de créditos con distribución por ocho periodos de cinco meses con una totalidad de cerca de 3.800 horas. El proyecto sigue todavia en estudios esperando se ponga en ejecución en marzo del año próximo y hace hincapie en los materiales orgánicos de manera a atender en la medida de lo posible la necesidad imediata de preservación del material etnográfico. A este respecto, aunque el Laboratorio de Conservación del Museo Nacional de Bellas Artes no trate especificamente de esta especialidad, sin embargo ha ya prestado servicio a petición del Museo de Antropologia de la Universidad de Sta. Catarina, haciendo que un funcionario del museo haga un cursillo corto con programa de trabajo definido en aquella especialidad. Lo mismo ha sucedido con relación al Museo Nacional de Quinta da Boa Vista, al orientar a su tecnico acerca del tratamiento de objetos de marfil.

2- LA CRACION DE UN SERVICIO REGULAR DE CONSERVACION EN EL M.N.B.A.

De regreso de nuestro entrenamiento en el Centro de la UNESCO en México, recibimos el encargo de estudiar la instalación de un laboratorio de conservación en el MUSEO NACIONAL DE BELLAS ARTES. Una investigación prévia de las condiciones señaló un espacio de utilización posible de cerca de sesenta metros de área, algunas instalaciones pequeñas - água, iluminación deficiente - una posibilidad remota de presupuesto y mucha basura.

Hay que hacer mención justa al imprescindible apoyo que ha sido proporcionado por la actual dirección, que a tiempo ha comprendido la necesidad de que se inicie un servicio regular de conservación de los valores culturales depositados en nuestras manos.

2.1- EL ESPACIO Y SU ADAPTACION

Los estudios preliminares nos han proporcionado una visión muy amplia del problema que básicamente ha sido planteado en dos partes: instalación de un servicio de conservación y la preparación de personal según criterios actualizados, para ~~darlo~~ asegurarle la continuidad necesária.

En función de las instalaciones existentes y siguiendo el criterio de mayor racionalización del trabajo, se hizo el aprovechamento del espacio, intentando instalar en ello todo lo minimo indispensable al funcionamiento de un laboratorio de Conservación (vease el plan, anexo 2), observandose desde la entrada: cámara oscura para revelado fotográfico y examen con luces especiales; estante para guardar materiales en utilización, encerado, mesa de mármol y lavatorios; mesa con equipo de precisión - lupa estereoscópica y microscópio, una gran mesa central para trabajos simultaneos, mesa de reentelado, mesa para higienizaciónes, sector de reintegración de partes en falta, papelera, y armaritos de pertenencias individuales y armario de acero para guarda de materiales.

El sector de examenes con luces especiales dispone de equipo para radiaciones UV e IR y monocromática de sódio.

En otra dependencia están los archivos que contienen toda la documentación de examen, proposición de tratamientos realicados con sus respectivos negativos y cópias fotográficas, materiales retirados para análisis y otras indicaciones componiendo el "dossier" de cada una de las intervenciones realizadas a cargo del laboratorio.

Siguiendo un cronograma de trabajo previamente elaborado, (anexo 3) fue posible coordinar las diferentes etapas de trabajo necesárias a la instalación del laboratorio, teniendose el cuidado de escalonarlas rigurosamente por orden de prioridad y de disponibilidad de presupuesto, por tres periodos de un año cada uno.

La observación del cronograma de actividades internas de implantación, (vease el gráfico), permite comprobar que el numero "I" ha sido completado con excepción de los dos últimos conceptos: sistema especial de eliminación de liquidos utilizados, renovación del aire, concepto de gran importancia y que está ya en fase de instalación. El número "II" resta pendiente solamente de la adaptación del espacio adecuado para Rayos X.

El número "IV" relativo a la documentación, ya tiene material reunido lo suficiente para una publicación proyecto este que aguarda todavia su vez.

La parte B del cronograma se refiere a las actividades complementarias a la instalación. De mucha importancia para nosotros, es la asociación del laboratorio a los demás Centros de Conservación. Al Instituto de Patrimonio Histórico e Artistico Nacional dependientes de la Directoria de Asuntos Culturales del Ministerio de la Educación y Cultura que a su vez depende como servicio del Museo Nacional de Bellas Artes. Esta el laboratorio desde el año pasado vinculado al Instituto International for Conservation -IIC- en calidad de miembro institucional. Buscaremos todavia, gradualmente la vinculación con los demás Centros de la UNESCO, con el objetivo de coordinación de programas.

El concepto de INTERCAMBIO, recibe una atención muy particular de nuestra parte, puesto que las solicitudes de orientación son tratadas con el cuidado que merecen, ya sea de forma directa, o dirigiendo a quien sea reconocida competencia. Estamos seguros de que es esta la mejor forma de hacer multiplicar la oportunidad que nos ha sido dada de mejorar nuestra experiencia, lo que es en verdad hacerlas transcender.

De las "Actividades Complementarias" concepto VII se ha ofrecido solamente la oportunidad de realización de un pequeño seminario al regreso al Brasil del Prof. Almir Paredes después de un periodo de especialización. *

3 RESUMEN DE ACTIVIDADES

En sus once primeros meses de actuación, el laboratorio del Museo Nacional de Bellas Artes se limitó a la tarea de proceder a la higienización regular de los objetos en exposición y en los depósitos. También su inmunización y algunas consolidaciones. Simultaneamente se ha empezado el registro de las distintos grados de humedad relativa, reultantes de las diferentes condiciones proporcionadas por la arquitetura del museo.

3.1- PREVISIONES Y ACTIVIDADES BASICAS

Para las actividades que acabamos de describir, a mediados del año inicial, fueron impuestas unas cuantas dificultades de naturaleza burocrátic-administrativas. Sin embargo una previsión de recursos materiales y de personal tuvo cabida en el ámbito de esta realidad, gracias no solo a la comprensión de la administración del museo, sino también con la ayuda efectiva de la Asociación de los Amigos del Museo de Bellas Artes- AMBAR.

La inclusión del laboratorio en el presupuesto general para el museo, solamente ha sido posible a partir del año de 1972, lo que nos hace esperar mejores perspectivas en los años venideros. De lo total del presupuesto, por aquel entonces ya bastante disminuido en función de los gastos anteriormente previstos, pudo el laboratorio absorber lo equivalente a cerca del ocho por ciento para adquisición de equipos, utiles y de materiales.

Las recomendaciones superiores en el sentido de una mayor austeridad con respecto a los gastos públicos, han impuesto una solución en el ambito mismo de los cuadros de personal del museo.

* N.R. Posteriormente a la presentación de esta comunicación al G.T en Madrid, tuvimos el seminario a cargo del arquitecto Olinto Coelho chefe del sector en el D.P.H.A. de Guanabara, al regresso de su [illegible] como becario de la UNESCO en el CENTRO DE ROMA.

Por esto, el laboratorio tiene dos funcionarios fijos. Otra razón de esto es que personalmente hemos dado preferencia a la formación de nuevos técnicos con stage previo de preparación en el laboratorio mismo, para futura selección y aprovechamiento. Esta es a nuestro entender, la otra actividad de importancia desarollada a partir de la instalación del laboratorio, sea, la formación regular de personal en ámbito regional, capaces de suceder a las generaciones de conservadores antiguos dando continuidad a su trabajo y experiencia. Pero esto lo sabemos bien, solamente resultará con la participación efectiva tanto de nuestros colegas brasileños con especialización en los Centros de Conservación de Bienes Culturales y también con la colaboración de los mismos centros.

3.3- FORMACION DE PERSONAL

En el mismo nivel de importancia dada a la Conservación del acervo en el Museo de Bellas Artes, según los criterios de lo que es modernamente la Conservación de los Bienes Culturales, está la formación regular de personal. A ello hemos dedicado mucho de nuestro esfuerzo. Hemos sido recompensados con el gran interés que tiene la conservación no solamente por parte do los estudiantes de museologia sino también de los de arte en la universidad. La prueba de este interés la hemos tenido en Sao Paulo donde invitados por la Universidad impartimos un curso intensivo de pos-graduación juntamente con nuestra colega Beatriz Pellizzette con el titulo de TECNICAS DE CONSERVACIÓN MUSEOLOGICAS. Lo mismo ha sucedido con el curso intensivo que por invitación del Departamiento de Cultura del Estado de Sta. Catarina, impartimos juntamente con la Prfa. Ecycla Brandão.

En principio establecemos un número límite de personal. Es que el estage nos ha parecido la mejor forma de trabajar con personal todavia no iniciado. Antes mismo de que su hubiera hecho cualquier convocatoria, las solicitudes para hacer experiencias de estage en el laboratorio del museo habian sobrepasado el número establecido. Así es que de pronto hemos dado inicio a la formación de personal, con un grupo de siete estudiantes, todos ellos en fase de conclusión de su curso en la universidad, a excepción de dos que ya han concluido su curso en la Escuela de Bellas Artes uno, y la Escuela de Museologia el otro. La selección de los canditatos al estage en

nuestro laboratorio, se basa preferentemente en los graduados de las escuelas de arte, de museologia, de fisica, química o biomédicas, las tres ultimas basta con que tengan los dos primeros años básicos (anexo 4).

El regimen de trabajo es en la forma de estage no remunerado, con la obligación de doce horas semanales. Se prevee para la totalidad del estage y para efecto de expedición de certificado de conclusión expedido por la dirección del museo, un total de 1600 horas sin interupción.

La forma de enseñanza se basa en una orientación individual de trabajo. Las actividades básicas del laboratorio en su comienzo son a nuestro entender las mismas por que deban empezar las experiencias de qualquier entrenamiento. Al gradual desarollo de la capacidad del laboratorio, sube el nivel de dificultades que deberá sobrepasar el estagiario. En sesiones de proposición puestas de tareas o de comprobación de resultados, hechas colectivamente con la finalidad de promover la integración de experiencias diversas, vividas al mismo tiempo. En estas sesiones, son impartidos entonces los criterios generales de conservación. Cada problema en particular empieza con una busqueda obligatoria en la bibliografia correspondiente, concluyende el estagiario en esta fase las etapas de examen de materiales, que componen el objeto en estudio, su naturaleza, constitución, formas de alteración, para establecer su grado de conservación. Se ha dado por primera vez en el museo, la importancia a la documentación de los trabajos de conservación, con un sentido de regularidad, en el que participa activamente el estagiario.

En los primeros once meses de experiencia, el estagiario tiene la oportunidad de pasar por todas las experiencias con los más diversos materiales. Los once meses restantes, el estagiario además de sus obligaciones en las tareas de naturaleza comun a todos, tendrá la oportunidad de desarollar un trabajo suyo en una de las muchas especialidades y defender su propuesta. A este trabajo, juntamente con la observación de su grado de interés vocacional se atribuye un concepto o nota final.

Ponemos de manifiesto la importancia que tiene en nuestro trabajo de formación de nuevos técnicos, la contribución efectiva de una bibliografia constantemente al dia.

Nuevas informaciones proporcionadas por nuestros colegas, obtenidas en cursos de especialización en los centros de conservación, [illegible] utilización de nuevos materiales o

nuevas soluciones con materiales tradicionales, son de gran importancia. Asi es que ya ponemos en ejecución un programa de conferencias, la primera ha tenido lugar a la llegada a Brasil del Prof. Almir Paredes despues de su estage en Lisboa. Tenemos programada una charla con el Prof. Olinio Coelho que ha estado trabajando en el Centro de Roma. Estamos tambien seguramente interesados en que los especialistas de la UNISCO que visitan profesionalmente paises de Latinoamérica, se detengan tambien por algun tiempo en Brasil, ya sea pronunciando conferencias o estudiando juntamente con nosotros problemas especificos de nuestra región.

4- INTERCAMBIO

Hemos ya puesto de relieve en este trabajo, la importancia del intercambio con los demás Centros ocupados con la Conservación de los Bienes Culturales de la humanidad.

A nivel regional, logramos un contacto más estrecho con algunos de nuestros colegas aunque bastante separados por las distancias. Contactos personales por correspondencia o incluso por telefono, nos hacen prever para dentro de un tiempo no muy lejano, una reunión de ambito nacional de conservadores.

Es importante una estrecha colaboración con los diversos institutos principalmente con los científicos de la universidad, tanto por la contribución en esta area, cuanto por la indispensable colaboración de la critica estética e histórica.

4.1- VINCULACIONES INTERNACIONALES

El laboratorio de Conservación y Restauro del Museo Nacional de Bellas Artes esta asociado en calidad de miembro institucional con el International Institute for Conservation. Por su actuación en el plano de la preservación de los bienes culturales de la humanidad aunque modestamente, espera recibir de los demás centros, la atención a su solicitud de adhesión. Esta solicitud, significa para nosotros más que nada un gran incentivo de actualización y no podemos olvidar que nuestros objetivos,incluyeron notoriamente la formación de una nueva generación de equipos de tecnicos en conservación.

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2/6

A CONSERVATION LABORATORY FOR THE TREATMENT OF UNDERWATER MATERIAL

by

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Presented to the Working Group of Underwater Archaeology at the 3rd Plenary Meeting of the I.C.O.M. Committee for Conservation, Madrid, 1972.

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Un laboratoire pour le traitement du
matériel sous-marin.

Synopsis.

En 1964 le gouvernement de l'Australie Occidentale a adopté un acte dont le but est de protéger les débris des navires naufragés près de ses côtes. Parmi les navires naufragés il y a quatre vaisseaux qui ont appartenu à la Compagnie des Indes Orientales Néerlandaises: le Batavia (naufragé en 1629), le Vergulde Draeck (naufragé en 1656), le Zuitdorp (naufragé en 1712) et le Zeewyk (naufragé en 1727), ainsi qu'un vaisseau anglais le Tryal (naufragé en 1622). Il y a aussi un nombre de navires coloniaux naufragés avant 1900. Selon cet acte le Musée de l'Australie Occidentale (the Western Australian Museum) est responsable pour les débris de ces vaisseaux et pour le matériel regagné. Un arrangement récent entre les Pays-Bas et l'Australie a cédé tous les droits sur les navires néerlandais au gouvernement australien avec la stipulation qu'une partie du matériel regagné sera retournée aux Pays-Bas. Le Musée de l'Australie Occidentale a la responsabilité d'examiner les sites, d'excaver les débris et de conserver et de préserver le matériel regagné.

Il est futile de conduire une excavation archéologique sous-marine sans avoir les moyens de traiter les objets sauvés. Or, un Laboratoire de Conservation et de Restauration a été établi pour le traitement. Le Laboratoire, à présent ayant 10 employés, est bien pourvu scientifiquement pour traiter le matériel regagné. Celui comprend des objets en bois, en os, en pierre; des céramiques, des tissus, du cuir et du métal.

Le Laboratoire consiste des sections de conservation et de préservation, ainsi qu'une section de photographie et un atelier. Il y a des cuves pour emmagasiner le matériel regagné et des facilités pour le traitement des objets aussi grands que les canons et les ancres.

A CONSERVATION LABORATORY FOR THE TREATMENT OF UNDERWATER MATERIAL

Introduction

Off the coast of Western Australia lie the remains of many wrecked ships. Although this is typical of Australian coastal waters, what is significant is that at least five of these wrecks pre-date by up to 150 years the better known discovery of the east coast of Australia by James Cook in 1770 and the subsequent colonising by the English.

In the seventeenth century the Dutch were a great trading nation and through their trading companies had posts scattered as far apart as the West Indies, Africa and the Orient. From 1611 when the vessels of the Dutch "Vereenigde Oostindische Compagnie" (known as the United East India Company and referred to as the V.O.C.) left the coastal route to the East Indies via Africa and India for the preferable "roaring forties" route, they sailed towards the coast of Western Australia before veering north. This resulted in at least four shipwrecks off the Western Australian coast (Fig 1) with one of them, the wreck of the Batavia in 1629 off Beacon Island in the Wallabi Group, Houtman Abrolhos, being infamous for the mutiny and massacres which followed. The remaining known V.O.C. wrecks are the Vergulde Draeck (1656) about 96 km N of Perth and approximately 5 km out to sea, the Zuytdorp (1712) at the base of cliffs approximately 65 km N of the mouth of the Murchison river and the Zeewyk (1727) off Gun Island in the Pelsart Group, Houtman Abrolhos. The earliest wreck, believed to be the English vessel the Tryal was wrecked in 1622 in the vicinity of the Montebello Islands.

In addition to these there are several hundred colonial (pre 1900) vessels recorded as being lost off the coast of Western Australia.

The discovery and later identification of these wrecks, in particular the Vergulde Draeck and Batavia in the early 1960s, led to intense activity by skindivers, especially when it was realised that the vessels had carried silver coins on board. The recovered material included objects of metal, ceramics, glass, wood, bone, stone and possibly leather, however, the lack of conservation facilities for this material and the fact that a great deal of it had no commercial value, resulted in the destruction of fragile and historically significant material. In addition, all the wreck sites show damage caused by the use of haphazard excavation techniques.

The existing legislation at that time was the Commonwealth of Australia Navigation Act of 1911 which although containing some provisions concerning shipwrecks is held to be irrelevant for the control of submarine archaeological sites comprising the remains of ships or their contents lost before the Commonwealth of Australia came into existance in 1901. This in fact includes virtually all the wrecks of historical significance to Western Australia. Therefore, in 1964 the Western Australian Museum was made responsible for the recovery and conservation of these wrecks by Western Australian State legislation (the Museum Act, 1959-64). This was revised in 1969 (the Museum Act, 1969, detailed in Appendix 1).

By this Act, two classes of historic wreck (which includes the remains of ships and disassociated material) are recognised.

These are :

(a) the remains of ships detailed in the Schedule to the Act which includes all V.O.C. wrecks, the Tryal plus a colonial wreck, the Cottesloe Wreck.

(b) all ships lost before 1900 and lying in the territorial waters of the State of Western Australia.

A person discovering a possible class (b) wreck must report it to the Trustees of the Western Australian Museum. If after investigation it is shown to be an historic wreck of significance, the State Minister responsible for the Museum may decide to vest it in the Trustees of the Museum. It is then treated as though it were a class (a) wreck. Alternatively the Minister may decide that it is not worthy of vesting and a note exempting it from the provisions of the Act will be published in the State Government Gazette.

The Act provides for payment of a reward up to A$2000 and also approved expenses for the reporters of wrecks. It also provides that the current gold or silver value of coin or bullion shall be paid to reporters of wrecks from which it is recovered. Penalties including imprisonment are included for violation of the Act.

Although this Act makes it legally possible to protect historic wrecks it is very difficult to actually enforce. Blasting and looting of the Vergulde Draeck wreck site and also the Tryal has occurred since the passing of legislation; several prosecutions have been initiated but to date no convictions have been obtained. The Museum therefore relies upon a wreck supervision programme for security using its own personnel as well as the assistance of local

skin- diving clubs. The necessity for good public relations between the Museum and these Clubs cannot be overstressed as here are the people most likely to find new wrecks and with the opportunity to remove material from existing known wrecks. Co-operation is achieved most successfully through the organisation of combined diving expeditions.

Due to various challenges to the validity of the Museum Act another step taken to protect the wrecks has been achieved by the Netherlands Government transferring to the Australian Commonwealth their title to the V.O.C. wrecks off the Western Australian Coast.

Ever since the discovery of the wrecks The Netherlands Government, as the legal successor to the V.O.C., although claiming ownership of the wrecks has always indicated its willingness to transfer this right to the Commonwealth Government on the understanding that The Netherlands will receive a share of the recovered material.

The Deed of Transfer and Agreement between The Netherlands and Australia concerning old Dutch Shipwrecks has now been signed and will operate under the following principles:

1. The Netherlands will transfer to the Australian Commonwealth all its right, title and interest in and to the wrecks of former vessels of the V.O.C. lying on or off the coast of Western Australia, and in and to any articles recovered from the wrecks including articles already recovered and in possession of the State of Western Australia and its authorities and also articles recovered before the Museum Act.

2. The historic wrecks are the national heritage of both Netherlands and Australia. Therefore a committee comprising two persons nominated by the Commonwealth and two by the Netherlands will be set up to determine the disposition and subsequent ownership of articles recovered from the wrecks.

3. As the cost of recovery of the articles far exceeds their intrinsic or antiquarian value then this expenditure can only be justified on the basis of the historic importance of the material. This means firstly that a representative collection of the wreck material should be deposited in the Museums of both The Netherlands and Australia and secondly, which is of more importance, that the material should not be dispersed to the point where historians are not able to reassemble and study the material when necessary. Therefore strict control of the secondary distribution within The Netherlands and Australia is essential. The bulk of the material will in fact be held in the Western Australian Museum. The institutions receiving material will be expected to contract not to disperse it further and to agree to allow its reassembly for study.

Necessity for a Conservation Laboratory

Having been given responsibility by the State for historic wrecks in 1964, the Western Australian Museum recognized that, for the safety of material in the wrecks which was liable to be unlawfully excavated, it must quickly set up a marine archaeological programme to systematically carry out excavation of the wreck sites. The wrecks soon began to yield large quantities of material including iron, wood, ivory, and some leather which if not treated and stabilised immediately following excavation would rapidly deteriorate. Therefore exercise of responsibility also included need for a well staffed and equipped conservation and restoration laboratory to treat the recovered material. Such a laboratory has been set up and to date has conserved material for the Western Australian Museum.

The agreement between the Netherlands and Australia concerning the ownership and distribution of the material recovered from the V.O.C. wrecks says nothing about the conservation and restoration of the material which is to go to Holland. Although Australia has contracted that the cost of search and recovery will not be paid for by Holland, it is to be hoped that the Western Australian Museum will not be asked to pay the total cost of conservation and restoration. The majority of material recovered requires urgent treatment and we consider thatit would be unwise to adopt a policy to apply only a temporary stabilisation treatment on recovery, with the result that the material designated for the Netherlands would be delivered to that country where it would be given a

final treatment. We are of the opinion that all the material should be completely conserved and restored in Australia. This will place a heavy load on the staff and facilities of the Western Australian Museum Conservation Laboratory and it is hoped that the Dutch Museums will recognize this load and help to bear it.

It can therefore be seen that commencing in 1964 it was imperative for the Western Australian Museum to establish a conservation and restoration laboratory to support the marine archaeology programme. The matter now becomes one of international museological importance as the result of the recently signed Dutch/Australian Agreement which will almost certainly require the laboratory to treat the material for Dutch Museums as well.

Establishment of the Conservation Laboratory

The Museum early sought the co-operation of the Dutch Government who sent out to Australia an expert, Mr G.D. van der Heide to advise on excavation and conservation techniques. Following Mr van der Heide's recommendations, the Museum sent to him two staff members for training in Holland under his guidance. One of these Mr H. Bingham a former naval Petty Officer Clearance Diver was trained to lead the diving team in excavation work and in late 1969 the other, one of the authors (Car) was trained in conservation and restoration techniques applicable to underwater material.

Although these were small beginnings with the same persons diving, surveying, excavating and treating the recovered material, from them subsequently developed well established marine archaeological and conservation departments within the Western Australian Museum.

The Department of Marine Archaeology now has a diving team of nine led by a trained marine archaeologist Mr J. Green, formerly of the Research Laboratory for Archaeology and the History of Art in Oxford. They are equipped with a work boat and other small craft, magnetometry and metal detecting equipment, air lift pumps etc., in fact all that is required to carry out a sophisticated marine archaeological excavation. This was demonstrated early in 1972 when over 9000 kg of material (excluding iron cannon and anchors) was recovered in three months from the V.O.C. wreck the Vergulde Draeck. This included copper and brass ware, 40 complete and many fragmented bellarmine jugs, leather shoe remains, wood, animal bones, elephant tusks, 7,000 silver coins and over 8,000 ballast bricks. This excavation was accompanied by an extensive and detailed survey of the wreck site.

During the same period the staff of the Conservation Laboratory has increased to ten, with facilities for treating the extremely varied types of material recovered from the sea.

The Head of the Laboratory Dr C. Pearson, a corrosion scientist, is assisted by a physical chemist Dr P. Colombera who is responsible for the analytical facilities of the Laboratory. Although rather rudimentary at present it is

hoped that they will soon be upgraded by the introduction of atomic absorption spectrophotometry and x-ray diffraction equipment. These facilities, along with x-ray fluorescence are at present provided by outside organisations. With the assistance of a graduate metallurgist who is studying the properties and conservation of underwater iron, plus two other technical assistants, Dr Pearson apart from being responsible for the Laboratory as a whole is chiefly concerned with the conservation part of the work. This covers the cleaning (e.g. the removal of encrustations and corrosion products) of objects recovered from the sea followed by their stabilisation (e.g. electrolytic reduction for iron) against further deterioration. Restoration is under the direction of Mr E. Car with the assistance of three technical assistants. This includes Mrs R. Car, formerly of the Central Conservation Laboratory in Amsterdam, who specialises in the restoration of textiles. Although restoration work is not always carried out on an object it does include repairing broken ceramics, re-shaping and patching metal objects and also the manufacture of replicas. The material at present being treated covers ceramics, glass, bone, ivory, metals, leather, stone, wood and textiles.

The Conservation Laboratory is divided into conservation, restoration and workshop areas. The laboratory facilities include pH-mV meters, conductivity meters, metallurgical microscope and polisher, stereoscope microscopes, ultra-sonic

cleaners, electrolytic reduction unit, radiographic facilities, airabrasive unit, dental equipment for restoration work and other general laboratory equipment. There are also photographic and darkroom facilities for the routine photography of objects before, during and after treatment. The workshop area contains a well equipped workshop and also large tanks and heavy lifting facilities for the treatment of large iron objects including cannon and anchors. Other equipment for this work includes a transformer rectifier (200A,40V), water-deioniser (700l/h) and a kiln (up to 1200°C) for thermal treatment studies.

One of the problems with underwater excavations is that due to the limiting factors of weather and sea conditions the excavations are invariably short but intensive yielding a large amount of material (e.g.9000 kg from the Vergulde Draeck in three months). As it is not possible to treat all the material immediately it must be stored in a stable environment, therefore outside the Laboratory are 14 large storage tanks to accommodate bulk material. Some of these contain fungicide treated water for the storage of wood and bone, others are available for the storage of large iron objects such as cannon and anchors. The aqueous storage of iron objects is a serious problem as they will continue to corrode if stored in uninhibited solutions. Research into the requirements of primary storage environments is currently being carried out in the Laboratory.

Other projects being investigated include a study of the properties and deterioration of silver coins and their relation to subsequent electrolytic reduction cleaning techniques. A study of cleaning and also restoration techniques for coral encrusted ceramics and glassware, and the treatment of seawater - logged leather. There is also a major research project into the properties, deterioration and subsequent treatment of underwater iron.

Although the Laboratory is staffed and equipped for specialising in the conservation of marine archaeological material, it is also responsible within the Museum for historical colonial material and ethnographic material including aboriginal rock paintings and engravings. It also provides a monitoring and advisory service concerning the museum environment for storage and display plus a scientific and analytical service to all museum departments.

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APPENDIX 1

EXTRACTS FROM THE MUSEUM ACT 1969 RELATING TO HISTORIC WRECKS

Section 6

"historic wreck" means :-

(a) any ship mentioned in the Schedule to this Act; and

(b) any other ship that was, or appears likely to have been, abandoned, wrecked or stranded before the year nineteen hundred and that is lying below low water mark in the territorial waters of the State that has not been declared under section 41 of this Act as not being an historic wreck for the purposes of this Act,

and any part of the hull, equipment, machinery, weaponry or other article of any class or kind belonging to, separated from, or that came from any such ship and that is so lying.

PART V. - HISTORIC WRECKS

38. Without affecting the generality of section 20 of this Act, the Museum Trustees may -

(a) with the approval of the Minister, pay to a person, who first notifies them, as provided by section 39 of this Act, of the finding of an historic wreck of which the existence was not previously known to the Trustees an amount not exceeding two thousand dollars;

(b) pay to a person, who at their request, delivers to them an historic wreck, the expenses properly incurred by him in recovering and obtaining possession of the wreck and an allowance for the work done in that regard, based on a rate determined by the Trustees prior to its being commenced;

(c) take possession of a wreck that is vested in the Museum pursuant to this Act, enter into an agreement for the recovery or partial recovery of the wreck or any part of the wreck, and with the approval of the Minister, expend such amount in that regard as is properly payable;

(d) take such steps as may be necessary or desirable to recover, preserve and display an historic wreck vested in the Museum;

and

(e) promote or supervise activities aimed at the discovery, recovery, preservation, study and display of historic wrecks.

39. (1) A person finding an historic wreck, other than such as is mentioned in the Schedule to this Act, -

(a) shall not damage, destroy or, except for the purpose of delivering it to the Trustees at their request, remove the historic wreck or any part thereof; and

(b) shall, as soon as practicable after the finding, give notice of it in writing, to the Trustees.

Penalty : Two hundred dollars

(2) A person wishing to receive the benefits accruing, under this Part, to the finder of an historic wreck shall mark the position of the wreck with a buoy, stake or cairn, identified in the prescribed manner; and the Trustees may refuse any claim of a person who has not complied with the requirements of this subsection.

(3) A notice given pursuant to subsection (1) of this section, shall -

(a) set out particulars of the finder, and the date of the finding, of the historic wreck;

(b) give a concise description of the historic wreck and particulars of the buoy, stake or cairn (if any) by which it may be identified; and

(c) give the location of the historic wreck.

(4) Where a person is in doubt as to whether any property that he has found is an historic wreck, he may, by notice in writing, refer the question for decision to the Museum Director whose decision is conclusive but shall be made within twelve months of his receiving the notice referring the question

or within such further time as the Minister, in any particular case, directs in writing; and, where a person referring a question to the Director, pursuant to this subsection, gives the information required under subsection (3) of this section, he is deemed, if the Director decides that the property is an historic wreck, to have given the notice required under subsection (1) of this section.

(5) A person who wilfully makes a false statement in any notice given to the Trustees pursuant to this section commits an offence.
Penalty : Two hundred dollars

(6) A person who, not being the finder of the wreck, wilfully moves, removes, defaces, alters or otherwise interferes with a buoy, stake or cairn placed or erected at or over a wreck pursuant to this section or removes, damages or destroys the historic wreck or any part of it commits an offence.
Penalty : Two hundred dollars or imprisonment for three months or both the fine and imprisonment.

40. (1) Where, after inspecting any wreck, the Director is of the opinion that the wreck is an historic wreck and is of national or local historical interest or is of scientific, archaeological, educational or other special national or local interest, he shall advise the Trustees accordingly and the Trustees may recommend to the Minister that the historic wreck be vested in the Museum, on behalf of the Crown, for the purposes of this Act.

(2) If the Minister approves of a recommendation of the Trustees made under subsection (1) of this section, the Governor may, by Order in Council, vest the historic wreck in the Museum.

(3) The historic wrecks mentioned in the Schedule to this Act are, by force of this subsection, vested in the Museum.

(4) Compensation is not payable to any person by reason that an historic wreck is vested in the Museum pursuant to, or by operation of this Act,

(5) Notwithstanding the provisions of subsection (4) of this section, but subject to the Banking Act, 1959 of the Parliament of the Commonwealth, where any gold or silver coin or bullion is recovered from an historic wreck that was notified to the Trustees pursuant to section 39 of this Act and is subsequently vested in the Museum, the Trustees shall pay to the person who first notified the Trustees of the finding of the historic wreck the market value in the State of the metal content of the gold or silver in coin or bullion as at the time the wreck was notified to the Trustees by that person.

(6) A person who -

(a) without the consent of the Trustees, in any way alters, removes, destroys or in any way deals with, or assumes the custody or control of, an historic wreck vested in the Museum pursuant to this section ;

(b) having the consent of the Trustees to do any

of the things mentioned in paragraph (a) of this subsection, is in breach of any condition to which the giving of the consent was subject, or

(c) impedes or hinders, or endeavours in any way to impede or hinder, any member of the staff or employee of the Museum or any person acting with the authority of the Trustees who is inspecting, recovering or otherwise dealing with an historic wreck, whether vested in the Museum or not,

commits an offence.

Penalty : Two hundred dollars or imprisonment for three months or both the fine and imprisonment.

41. (1) Where, after inspecting an historic wreck, the Director is of the opinion that the wreck is not of national or local historical interest or of scientific, archaeological, educational or other special national or local interest, he shall advise the Trustees accordingly and the Trustees may recommend to the Minister that the provisions of this Part should no longer apply to the wreck.

(2) If the Minister approves of a recommendation made under subsection (1) of this section, he may authorise the Trustees, by notice in the Government Gazette, to declare that the wreck specified is not an historic wreck for the purposes of this Act.

42. (1) Subject to subsection (2) of this section, where a person has in his custody or under his control any object that belonged to, or was taken or recovered from, an historic wreck mentioned in the Schedule to this Act and which was taken or recovered from the territorial waters of the State below low water mark,before the eighteenth day of December, nineteen hundred and sixty-four, he shall forthwith send notice in writing to the Director of that fact.
Penalty : Two hundred dollars.

(2) The provisions of subsection (1) of this section do not apply to a person who has in his custody or under his control an object referred to in that subsection if -

(a) that or some other person has, before the coming into operation of this Act, given notice in writing to the Director as required by subsection (1) of section 20C of the Museum Act, 1959-1964, in relation to that object; or

(b) that or some other person has previously given notice in writing to the Director as required by subsection (1) of this section in relation to that object.

(3) In any proceedings for an offence against subsection (1) of this section the fact that -

(a) the object to which the proceedings relate was taken or recovered from the territorial waters of the State below low water mark before the eighteenth day of December, nineteen hundred and sixty four ; and

(b) no notice as described in paragraph (a) or (b) of subsection (2) of this section has been given in relation to the object,

shall be deemed to be proved in the absence of proof to the contrary.

(4) Where -

(a) the Director has received notice in writing from a person pursuant to subsection (1) of this section in relation to an object; and

(b) the Director is of opinion that the object is likely to be of national or local historical interest or of scientific, archaeological, educational or other special national or local interest,

the Director may, in writing, notify the person accordingly.

(5) A person to whom notice is given by the Director under subsection (4) of this section -

(a) shall not sell, purport to sell, destroy or otherwise dispose of the object to which the notice relates, until he has sent to the Director notice in writing of his intention and has obtained the written permission of the Trustees to do so; and

(b) shall, if required by the Trustees, produce the object to them at such reasonable time as is specified by them for inspection and possession by them for the purposes of subsection (6) of this section.

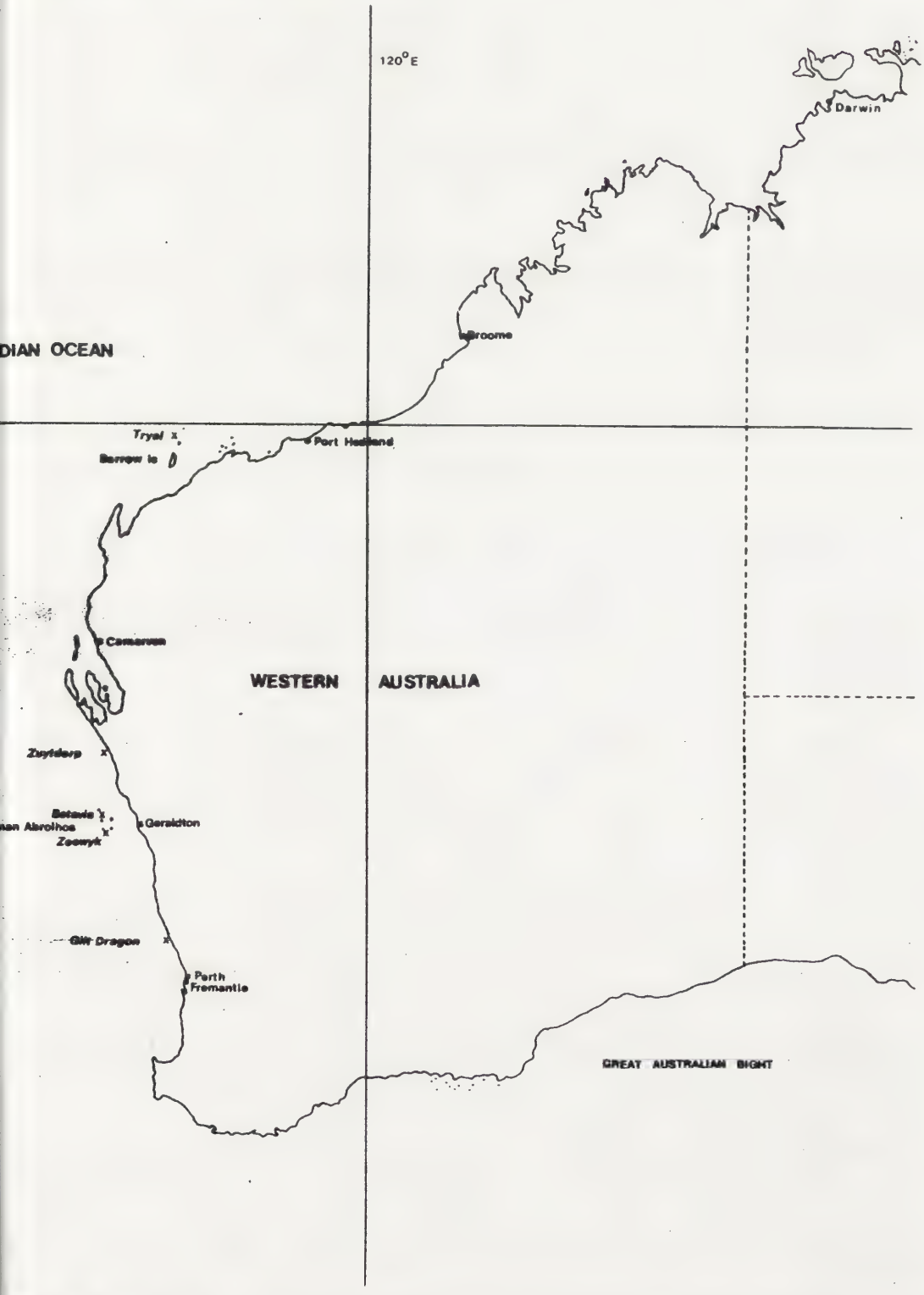
(6) Where, after inspecting any object produced pursuant to paragraph (b)of subsection (5)of this section, the Director is of the opinion that it is of national or local historical interest or of scientific, archaeological, educational or other special national or local interest, the Trustees may continue in possession of the object for a period of thirty days or for such longer period as the person producing it and the Trustees may agree upon, for the purpose of photographing, copying, or otherwise obtaining a record of, the object and investigating the extent of any such interest that the object may have.

(7) At the expiration of the period mentioned in subsection (6) of this section, the Trustees shall, unless they and the person producing it otherwise agree, return the object to him.

(8) Where the Trustees have made a record of an object as provided by subsection (6) of this section or do not require to make a record of the object they shall by authority in writing permit the object to be sold, destroyed or otherwise disposed of by the person producing it.

(9) A court convicting a person of an offence against subsection (1) or subsection (5) of this section shall, in addition to imposing any other penalty, order that the object to which the offence relates be forfeited to the Crown for the use of the Trustees, and any order so made has effect according to its tenor.

Shipwrecks off the Coast of Western Australia



SERVIÇO PÚBLICO FEDERAL

MUSEU NACIONAL DE BELLAS ARTES
Laboratorio de Conservação e Restauro

NORMAS PARA ESTAGIOS EN EL MUSEO NACIONAL DE BELLAS ARTES

El Museo Nacional de Bellas Artes ofrece la oportunidad de estágios con derecho a certificado a los candidatos que rellenen adecuan los seguintes requisitos:

a) Para la Sección Técnica- haber cursado la Escuela de Museologia, o la Escuela de Bellas Artes de la U.F.R.J. o el Curso Superior de Historia del Arte e de Arte Decorative del Instituto de Bellas Artes de la GB.;

b) Para el Sector Educativo- haber cursado la Escuela de Museologia, Escuela de Bellas Artes, Pedagogia, e Psicologia (en grado de licenciado las tres ultimas).

c) Para el Laboratorio de Conservación e de Restauro- haber cursado la Escuela de Museologia, Bellas Artes asi como los que tengan concluido los años básicos en Quimica, Fisica, e Biomédicas;

d) Excepcionalmente para atender a la necesidade de entrenamiento de personas en trabajo efectivo en los museos, que sean recomendadas por sus respectivos directores.

Normas a serem observadas por los estagiarios

1- Las actividades de estagio tendran un programa de trabajo propuesto por el interesado en el estagio e orientado por lo tecnico respectivo del museo en aquella especialidad.

2- El estagiarño tine a su cargo la obligación de un número

determinado de horas de actividades-hora, en atención a las necesidades de cada ~~sector~~ seccion.

3- El tiempo de duración del estágio es de doce meses, para el Setor Técnico e de Educación e de vinte e dos meses para el Laboratorio de Conservación e de Restauración.

4- Al estagiario le toca ejecutar las tareas que le sean destinadas por su orientador, en los plazos por el determinados el titulo. Dichas tareas consistirá en actividades de ~~xxxxxx~~ naturaleza regular, a las de la Seccion respectiva. El estagiario deberá desarrollar aun, tema original de investigación, objeto de ~~pesquisa~~ monicion, a la orientación en el tiempo ~~para el~~ a ello destinado. El referido trabajo de investigación será objeto de apreciación para mesurar el grado de aprovechamiento del estagiário.

5- No es permitido a qualquer estagiário firmar documentos que no tengan relación directa con su trabajo de estágio e sin previo conocimiento de su orientador. Se considera la transgresion a esta norma motivo de interupción inmediata del estagio.

6- Una vez terminado el estagio, el estagiario presentará a la Dirección un informe dentro de un mes a seguir a la conclusion del entrenamiento.

7- Un otro informe deberá ser sometido al Museo Nacional de Bellas Artes dando cuenta de sus trabajos en la especialidad e los resultados de la aplicación de sus conocimientos, despues de un año de conclusión del entrenamiento.

8- Al estagiario no es permitido el ingreso en los depósitos, montagem de exposiciones e arquivos sin previa comunicación e la respectiva autorisación de su orientador o responsable por el estagiario directamente.

9- Se recomienda al estagiario el mayor cuidado con los objetos, aparatos, instrumentos, libros e documentación puestos a

su disposición por el orientador. En el caso de daño será determinado el nontante a ser repuesto por el estagiario, comprobada su descaso.

10- El estágio en la forma de que trata el presente regulamiento, puede ser considerado interrompido sin cualquer compromiso del M.N.B.A. toda vez que asi juzgar la dirección por no se haber de alguna forma observado lo que dispone el presente documento.

THE SETTLEMENT OF THE CONSERVATION AND RESTORATION LABORATORY OF THE MUSEU NACIONAL DE BELAS ASTES - RIO DE JANEIRO

Announcement to the 3thd Meeting of the Commitee for the Conservation of the "I C O M" - Conseil International des Musées - MADRID 1972

by SERGIO GUIMARAES DE LIMA (responsible for the Conservation Laboratory of the M.N.B.A. at Rio de Janeiro

of the Fine Arts Institute of S.C. GB State
Filiation to the ICOM insc. 6237
Filiation to the IIC. and IIC AG.

SUMMARY

1. Sources of the establishment of the Rio de Janeiro National Fine Arts Museum Patrimony. The dismemberment of the original didactic collection for the settlement of the Museum.

1.1- Problems connected with the conservation of this Patrimony. The restorer and his formation in the painting courses of the Fine Arts School. The degeneracy of the formation process on account of the general revolution of modern art and the following changements at the teaching methods.

1.2- Towards professional preparation of the restorer, levels must be observed, such as: a) regular; b) not regular ; and c) specialized - Scholarships abroad.

2 - Institution of a Conservation and Restoration Laboratory in the Rio de Janeiro National Fine Arts Museum, and the training of specialized staff, all based in the determinations of the statement entitled "Compromisso de Brasilia (Appointment at Brasilia), dated april 1970 in

in attachment to its 7 and 10 paragraphs. The organization of the Laboratory in its destinated area, since planning and installation till purposed ways including budget and chronogram.

3.-Summary of the activities next to the settlement of the Laboratory in its first eleven months of work; foresights, initial activities, STAFF TRAINING, in accomplishment of stages, seminars and lectures.

4.-Interchange with the foreigners centers IIC and connections supervised by the Cultural Affairs Department (Departamento de Assuntos Culturais-MEC) of the Education and Culture Ministry IPHAN.

The International Council of Museums -
Committee for Conservation

Conseil International des Musées
Comité pour la Conservation

Madrid: October 2-8, 1972

G.Z. Bykova et A.V. Ivanova - Moscou

PEINTURE DE CHEVALET EN DETREMPE A LA COLLE

MATIERES, TECHNIQUE, TRAITEMENT DE RESTAURATION

A la fin du XIX siècle presque toutes les peintures de chevalet et les peintures murales en Russie étaient exécutées avec les couleurs à l'huile. Si auparavant les matières picturales se préparaient par les peintres eux-mêmes, maintenant, dans l'époque du développement de l'industrie, quand une production des couleurs de la peinture appartenait aux fabricants, les artistes se sont trouvée obligés d'acheter les couleurs d'une composition inconnue. A la limite du XXe siècle les firmes étrangères en concurrence produisaient plusieurs centaines de dénominations des couleurs artistiques. Les peintre ne connaissaient plus les propriétés des couleurs; la technologie ancienne était négligée, car elle ne correspondait pas toujours aux nouvelles tendences dans l'art, ainsi qu'au rythme accéléré de l'exécution des tableaux. Il n'y a rien de surprenant que la détérioration des peintures, peintes au XIXe siècle est devenue une chose très répandue.

A ce temps où la technique de la peinture à l'huile est tombée en décadence, on a commencé à parler de la peinture à la détrempe. L'intérêt qu'on lui voua s'explique d'une part par ce que les artistes ne pouvaient ne pas remarquer une bonne conservation des tableaux des maîtres anciens, et d'autre part par la tendence à une manière décorative et aux surfaces peintes mates que l'on pouvait observer du côté d'un certain groupe de peintres de cette époque. Or, ces derniers ont été amenés par tout cela à l'emploi de couleurs aux liants à base d'une colle ou à base d'une émulsion.

La limite du XIX et XXe siècle est une époque d'épanouissement de l'art de décoration de théâtre. Les peintres, tels

que K.A. Korovine, M.A. Vroubel, V.A. Serov, A.Ia. Golovine, N.K. Rerikh, A.N. Benois, L.S. Bakst et les autres sont venus travailler eu théâtre.

Les maquettes des décors, esquisses des costumes, décorations théâtrales, ainsi qu'ébauches, panneaux décoratifs, placards, portraits et tableaux, sont le plus souvent exécutés dans la technique de la détrempe à la colle. Les oeuvres remarquables de ces peintres se sont presentées dans les collections de tous les musées de l'URSS ou presque.

A.I. Golovine est un de ces maîtres, un grand artiste, qui avait le coup d'oeil juste. Une grande collection de ces ébauches, maquettes des décors et tableaux se conserve au Musée Russe (Léningrad). La technique de ce peintre est bien compliquée. D'après ce que disent ses contemporains, il avait l'habitude de mélanger sur sa toile quatre matières différentes à la fois: la couleur à la colle, dont on se sert pour peindre les décorations, la détrempe, la gouache et puis il incorporait dans ces couleurs encore humides le pastel. Le résultat de cette technique est que presque toutes ses peintures nécessitent d'un traitement de restauration.

Les oeuvres modernes (1), exécutées dans la technique de tempera à la colle, sont dans leur majorité un ensemble très complexe de matières picturales diverses. Presque toujours il s'agit de détrempe, gouache, aquarelle, carbon, pastel. La régularité dans l'utilisation de ces matières lors de l'exécution d'une oeuvre ne peut être révelée qu'avec grande peine. Dans certains cas la détrempe peut être mélangée à la gouache lors du processus de travail: mais à cela un certain coup de pinceau peut contenir plus de gouache, tandis qu'un autre contiendrait plus de détrempe. Parfois un peintre applique les touches de gouache au-dessus de la couche de tempera, et dans d'autres cas inversément il pose la détrempe sur la gouache. En ce qui concerne le pastel et le carbon, dans bien de cas ils se trouvent au-dessus des couleurs, mais dans certains cas ils couvrent la gouache, dans d'autres la détrempe.

Il existe une grande variété de supports et de préparations de la peinture en détrempe à la colle, qui sont plus ou moins conformes à cette technique.

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(1) Nous classons parmi les peintures modernes de chevalet en détrempe à la colle une peinture exécutée dans une technique pareille à partir de la fin du XIXe siècle.

A en juger d'après les sources littéraires, d'aucuns estiment que la peinture à la détrempe et à la gouache, grâce à ses propriétés et à sa composition, offrent à un peintre une grande liberté dans son travail, sans le contraindre à suivre tel ou tel procédé.

Cependant, comme l'a démontré la pratique de restauration, c'est justement dans ces cas où l'artiste ne suit pas strictement les méthodes techniques de la peinture et ne tient compte des propriétés des matières employées que les peintures se détériorent le plus souvent.

La particularité principale des couleurs de détrempe à la colle est qu'elles doivent être diluées à l'eau; cette technique donc écarte la manière empâtée. La peinture en détrempe et celle à l'huile imposent des techniques différentes; l'emploi de procédés techniques propres à la peinture à l'huile dans la peinture à tempera serait une grande erreur d'ordre technologique, qui entraînerait inévitablement la dégradation des peintures.

Le peintre qui travaille en détrempe doit considérer les tons des couleurs non seulement comme un simple mélange sur la palette, mais comme un ensemble de couches superposées. Quel que soit le support, il doit peindre avec des couleurs diluées, ne recourant aucunement à l'aide d'un couteau à palette.

Quand il est nécessaire de changer le dessin, par exemple dans le but de bonne conservation de la peinture, il vaut mieux appliquer plusieurs couches de couleur diluée, qu'une couche empâtée.

Quand on peint avec des couleurs telles que le blanc de plomb, la garance, l'outremer, le noir d'ivoire, l'ocre, il est nécessaire d'être bien prudent, car ces couleurs susmentionnées ont tendence à se craquer et se détacher du support, même si elles étaient posées en couche mince.

La restauration des peintures de chevalet à la détrempe des artistes du XIXe et XXe siècle offre des grandes difficultées. Premièrement, la pratique de la restauration de la peinture en détrempe moderne en comparaison à celle de la peinture à la détrempe russe ancienne, n'est pas grande.

Deuxièmement, les colles traditionnelles (la colle de poisson, la colle de peau, la gélatine, l'oeuf, etc.) ne conviennent pas à la fixation de la peinture en détrempe à la colle: en effet, étant donné l'absence d'une pellicule protectrice, l'imprégnation de la couche picturale par ces liants provoquera des chan-

gements de ton lors du fixage. En outre un restaurateur qui utilise ces matières doit toujours enlever l'adhésif en excédence de la surface peinte à l'aide de l'eau, ce qui est exclu dans le cas de la peinture en détrempe.

Le processus du fixage de la peinture en détrempe à la colle moderne, plus que les autres genres de peinture, nécessite de beaucoup de soins, de précautions et chaque cas doit être considéré comme un cas particulier.

Les analyses des propriétés des matières naturelles employées pour le fixage ont permis de conclure qu'elles avaient un nombre d'inconvénients essentiels, et ce n'est pas toujours qu'on a reussi à y remédier par les recherches d'une meilleure technologie de leur emploi. Cela nous amène à la nécessité de recherches sur les matières, qui pourraient donner des résultats plus satisfaisants.

Notre industrie nous offre un grand assortiment de composés de grande masse moléculaire synthétiques, qui possèdent des propriétés et des possibilités technologiques de leur utilisation les plus variées. Dans certains cas les polymères avec les propriétés prévues par avance peuvent aussi être fabriqués.

Cependant les polymères synthétiques n'ont pas encore trouvé de vastes applications dans le domaine de la restauration. Ceci s'explique par le fait que les restaurateurs ne connaissent malheureusement ni propriétés, ni technologie de l'emploi des nouvelles matières synthétiques, prétendant que les matériaux naturels sont mieux controlés par le temps et plus faciles à employer.

Afin d'apprécier les qualités positives et négatives des polymères, d'argumenter leur choix et leur emploi technologique, les restaurateurs sont obligés de bien connaître la structure des polymères et leurs propriétés chimiques et physico-mécaniques. Seulement l'étude approfondie des polymères et leur utilisation raisonnable permettront d'améliorer la qualité des travaux de restauration. Malheureusement les cas sont fréquents où les restaurateurs emploient l'une ou l'autre matière pour la fixation, sans tenir compte des propriétés physico-mécaniques et chimiques les plus élémentaires, ce qui mène parfois à une qualité inférieure des travaux de restauration et provoque même l'endommagement complet des oeuvres d'art.

Le principe de la fixation de la peinture par les polymères ne diffère en rien de celui effectué à l'aide des matières tra-

ditionnelles d'origine animale ou végétale: de la même façon on incorpore le liant complémentaire, qui peut provoquer l'altération des tons picturals due à une grande densité d'écailles de couleur et à leur imprégnation par l'agglutinant (quand il s'agit d'une couche picturale pulvérulente). C'est pourquoi la définition des propriétés techniques, auxquelles devraient répondre les matériaux de restauration employés, joue un rôle primordial.

Voici les principales propriétés techniques:

Les propriétés physico-mécaniques:

1. résistance à l'eau;
2. incoloration;
3. résistance à la lumière;
4. absence d'un rétrécissement pratique;
5. pellicule mate;
6. une bonne adhésion avec les différentes matières;
7. propriétés élastiques - les colles non-cassantes;
8. intervalle de température (+60° - 30°C).

Les propriétés chimiques:

1. inértie à l'égard des matières picturales (les pigments, liants);
2. pH - proche de celui neutre.

Les propriétés biologiques:

1. résistance biologique.

Les propriétés technologiques:

1. pénétration facile dans les matières poreuses (l'imprégnation);
2. bonne mouillabilité de la surface (l'imprégnation, le collage);
3. pression spécifique minime lors du collage (50-100gr.sur 1cm^2);
4. solubilité réintégrative (l'enlèvement de la pellicule).

Donc, une condition générale et principale - c'est la stabilité physico-chimique des matériaux, employés pour la restauration d'une peinture, se trouvant dans un certain milieu, qui devrait éliminer la possibilité d'un vieillissement rapide dû à une oxydation accélérée, aux effets des variations d'humidité et de température, etc.

La conformité à ces éxigences assurera une durabilité mécanique de la couche picturale soumise à la fixation, ainsi qu'une bonne adhésion entre elle et le support.

En partant de l'analyse de la nature des dégâts des peintures en détrempe à la colle ainsi que d'une pratique de restauration, on peut classer les matières employées dans la restauration en deux groupes: a) matières d'imprégnation et de fixation; b) matières de collage.

Toutes les oeuvres suivant la nature de leurs dégâts peuvent être divisées en trois catégories:

I- a) peintures qui présentent la pulvérulence de la couche picturale (le manque d'un liant dans les couleurs);

b) peintures qui présentent la pulvérulence de la couche picturale et son détachement du support en même temps (le même résultat du manque d'un liant);

II-l'écaillage, le détachement de la couche picturale du support et des couches inférieures (les causes: l'excédence du liant dans la couche supérieure, une faible adhésion entre les couches due à une technique mal choisie, et à la fragilité des couleurs);

III-l'ensemble des dégâts I et II.

I. Restauration d'une couche picturale pulvérulente

(qui peut "souiller", ou qui peut "souiller et s'écailler" en même temps), se fait en général quand il s'agit de peintures à la gouache ou de peintures exécutées dans la technique mixte: gouache et carbon; gouache et pastel; gouache et un peu de détrempe.

Les supports peuvent être variés: papier, carton, toile, contreplaqué. Le plus souvent dans cette technique sont exécutés les placards, esquisses, ébauches.

Le fixage des peintures, présentant les dégâts susmentionnés, se fait par la solution des matières fluoroplastiques à 1%-6H ou F-26L.

Les matières fluoroplastiques F-26L et 6H se caractérisent par une bonne adhésion et par l'élasticité des films. Les solutions de ces matières possèdent une bonne mouillabilité et pouvoir imprégnant, un index de réfraction bas (1,37); les revêtements obtenus conservent bien leur couleur et la texture de la couche picturale. Grâce à une bonne mouillabilité des solutions on peut

obtenir leu répartition uniforme sur la surface de la couche picturale sans coulées et sans éclat.

Les examens effectués par (l'Institut de recherches des matières plastiques polymérisées) ont démontré que ce n'était pas la dissolution des matières fluoroplastiques dans un seul dissolvant isolé, mais celle dans un mélange de plusieurs dissolvants, qui avait permis d'obtenir les meilleurs résultats.

Le choix d'un dissolvant depend de sa destination. Ainsi, pour préparer les solutions de viscosité basse, que l'on utilise le plus souvent pour le fixage de la couche picturale pulvérulente, il faut choisir les mélanges des dissolvants organiques, qui pourraient assurer une évaporation lente de ce dissolvant de la solution du copolymère. Autrement, si la vitesse de l'évaporation est grande, la solution du copolymère n'aurait pas le temps d'imprégner d'une façon uniforme et de pénétrer dans toute l'épaisseur de la couche picturale d'une pellicule brillante. C'est pourquoi il est utile d'employer les mélanges qui auraient une vitesse d'évaporation plus lente et donneraient une solution du copolymère à une viscosité basse. A ce fin on recommande les mélanges des dissolvants dans les proportions suivantes:

a) acétate d'amyle - acétone - acétate d'éthyle 1:2:2;

b) cyclohexanone - cellosolf d'ethyle - acétone - acétate d'amyle - acétate d'éthyle 2:3:3:6:6;

c) acétate d'amyle - toluène - acétone - acétate d'éthyle 3:3:4:10;

d) xylol - acétate d'éthyle - acétate d'amyle 2:3:5.

On e effectue le fixage comme suit:

On traite au préalable toute la surface (par le pulvérisateur) avec un mélange d'alcool et eau (1:1) ou d'alcool, eau et acétone (1/2:1:1) pour dépoussiérer la peinture. Ceci facilite le mouillage de la surface et rend le fixage plus efficace.

Avant de procéder au traitement préalable, il est nécessaire d'essayer le mélange recommandé avec un pinceau sur une petite partie de la surface de peu d'importance.

Si les couleurs se composent de colorants organiques, on ne peut pas employer le mélange alcool-eau, car au cours du traitement ces colorants se dissoudront et apparaîtront sur la surface même à travers plusieurs couches de couleur; dans ce cas

il faut utiliser le mélange suivant: 1 partie d'acétone, 1 partie d'eau et 1/2 partie d'alcool.

Le séchage de la surface terminé, on procède à la fixation, qui se fait du côté face avec la solution à 1% d'un des mélanges susmentionnés. Il serait souhaitable d'effectuer ce traitement au moyen d'un pulvérisateur. Etant donné un dégré de détérioration différent de chaque couleur, qui nécessite d'une quantité de liant variée, il faut découper d'un papier épais les patrons pour couvrir avec eux les zones séparées de la couche picturale, en commençant par les plus endommagées; changeant et déplaçant ces patrons on peut obtenir une fixation uniforme et solide de toute la surface de la peinture.

Il vaut mieux faire le fixage avec une solution à 1% plusieurs fois, plútôt qu'une seule fois - avec une solution plus concentrée, parce que les composés de faible concentration pénètrent plus facilement dans la peinture et donnent de meilleurs résultats de fixation. Afin de vérifier ces résultats on peut procéder comme suit: après séchage et stabilisation (3 jours après le fixage) on pose sur une partie traitée une feuille de papier à filtrer (ou papier à écrire poreux), on la frotte avec la main et puis on regarde s'il reste l'empreinte de la couleur sur le papier ou non. Il va sans dire que tout cela se fait sur une petite partie peu importante de la surface. En cas d'absence de traces de couleur sur le papier, on peut continuer ce contrôle avec un tampon d'ouate.

Si l'on constate que le fixage n'était pas suffisant, on peut le répéter encore quelques fois. Pour avoir la possibilité de contrôler l'état de la couche picturale, l'application de la nouvelle couche de liant ne doit s'effectuer qu'après séchage de la surface peinte. Lors de cette opération il faut veiller à ce qu'une pellicule brillante ne se forme pas, car son apparition indiquerait une sursaturation de la couche picturale par liant.

Les peintures qui ont subi le traitement de fixage ne doivent être conservées ou présentées que sous une verre, parce que leur surface, mate et poreuse, a une forte tendence à se souiller.

I - b) Si nous sommes en présence d'une pulvérulence et d'un écaillage de la couche picturale (ce genre de dégâts est assez fréquent, parce que les peintures modernes en général sont exécutées en plusieurs couches, où la gouache et le carbon s'alternent avec la détrempe), ce n'est pas toujours que nous povons réussir à éliminer ces endommagements, en agissant

avec une seule matière fluoroplastique.

S'il s'agit de pelliculage d'une couche picturale mince, on peut tenter de la fixer par la matière fluoroplastique 6H, mais les résultats obtenus ne seront pas toujours bons. Comme lors de l'encollage de la couche picturale, la force de la pellicule, formée par la solution à 1% ne sera pas assez forte pour qu'elle puisse retenir les parcelles de couleur détachées, et on est obligé d'augmenter l'épaisseur du film. Cela n'est pas si facile à faire, et par ailleurs amène à l'apparition d'un éclat sur la surface peinte (dû à une pellicule).

L'enlèvement de cette pellicule n'est pas toujours souhaitable et dans certains cas, à savoir quand la couleur est recouverte de carbon et de pastel, il n'est même pas possible.

Une autre difficulté technique consiste dans le fait que les résines à base de dissolvants organiques ne sont pas à même de ramollir le liant aqueux à la colle de la couleur et ne peuvent donc pas écarter les déformations. Dans ces cas, on emploie une dispersion aqueuse d'acétate de vinyle et 2 éthyle-hexylacrylate (AV-2EHA).

II. L'écaillage, le détachement de la couche picturale

de son support s'observent en général sur les peintures à la détrempe (à la caséine-huile), exécutées dans une technique empâtée sur les préparations émulsives de production de fabrique, ainsi que sur les peintures à la détrempe, combinée avec la gouache. L'écaillage se présente souvent sous forme de craquelures rigides aux bords soulevés.

Des résultats satisfaisants de la fixation de ces détériorations ont été obtenus par l'emploi de AV-2EHA. Les dispersions aqueuses du copolymère d'acétate de vinyle avec 2 éthyle-hexylacrylate, ainsi que de plusieurs autres copolymères, ont de bonnes propriétés physico-mécaniques et sont bien durables. Maintes fois déformées, elles sont néanmoins résistantes au vieillissement, incolores et possèdent en outre une série de qualités positives qui nous permettent de les considérer comme matières répondant entièrement aux principales propriétés que l'on attend d'un bon fixatif.

Les films à base de AV-2EHA, comparés avec le polyacétate de vinyle pur, sont plus résistants à l'eau, aux effets de l'atmosphère, à la lumière et au froid.

La comparaison des propriétés du polyacétate de vinyle avec celles de ses copolymères a démontré que l'emploi de ces-derniers

dans le domaine de la restauration est bien fondé et serait préférable à l'emploi du polyacétate de vinyle pur (homopolymère) bien que actuellement celui-ci ait trouvé des applications vastes en l'URSS ainsi qu'à l'étranger, tandis que ses copolymères restent malheureusement sans être utilisés.

Comme dispersion aqueuse, AV-2EHA s'est montré capable, en ramollant la couche picturale, de lui donner une élasticité et de contribuer à son autocollage sur un support (dans la plupart des cas sans être serré).

Grâce à sa pellicule mate et élastique, AV-2EHA ne défigure en rien la surface peinte et n'altère pas les qualités esthétiques de l'oeuvre.

Avant fixation, la surface peinte doit être traitée par un liquide polaire, de la même manière qu'avant fixation de la couche picturale pulvérulente. AV-2EHA de la production de fabrique a une concentration de 56%; il peut être facilement dilué dans l'eau en proportions variées.Il est recommandable de travailler avec un mélange fraîchement préparé, donc il faut le préparer seulement pour qu'il puisse être usé pendant 2-3 jours, pas plus. Il est nécessaire d'agiter de temps en temps le mélange, pour empêcher la précipitation des particules de la dispersion. Il serait souhaitable de mettre le mélange destiné aux différents tons, dans un vase isolé, pour qu'il ne soit pas mouillé par les particules menues de la couleur, qui peuvent tomber du pinceau au cours des manipulations. Le restaurateur, employant AV-2EHA doit observer strictement une règle essentielle: il vaut mieux imprégner la peinture plusieurs fois avec une solution de faible concentration, plutôt qu'une seule fois avec une solution de forte concentration, en raison d'une pénétration plus profonde de la solution liquide, qui permet d'obtenir une fixation plus solide, en évitant en même temps la formation d'une pellicule sur la surface peinte.

Donc, on recommande de commencer l'opération de fixage avec une solution à 1-2%. Sous les couches les plus denses et épaisses on pourra ensuite injecter une dispersion à 5%. Le restaurateur est obligé à vérifier la concentration de la solution, le mode d'opération et la quantité des couches appliquées, en faisant ses essais sur un endroit de la surface de peu d'importance, séparément pour chaque cas particulier.

La quantité des couches appliquées peut varier infiniment. En général, dans les cas de pelliculage de la couche picturale non compacte, ainsi que dans les cas de pulvérulence avec l'écaillage de la couche picturale, on utilise une solution à 1% et on répète l'imprégnation 2-3 fois.

Plus dense et empâtée est la peinture à traiter, avec les taches épaisses, plus forte la concentration de dispersion à employer (jusqu'à 5-8%); cependant, une première imprégnation doit se faire obligatoirement avec une solution à 1-2%, et ce n'est qu'après cela qu'on peut traiter les fragments détachés par la dispersion à 5-8%.

On effectue le fixage du côté face. Le mélange s'applique par des pinceaux doux (en poile de kolonok, N 2 - N 8). On peut appliquer la deuxième couche de fixatif sur la première encore fraîche (si, lors du séchage, on sent le manque du liant introduit), ou déjà sèche, dans un laps de temps plus ou moins bref.

Au cours du fixage il est nécessaire de veiller constamment à ce que sur la surface ne s'accumule pas le mélange superflu, car ceci peut amener à l'apparition de l'éclat. Si le mélange est encore humide, ou s'il vient de sécher, on peut l'enlever sans peine avec un tampon d'ouate, mouillé avec de l'eau. Après séchage de la pellicule, l'éclat peut être éliminé par tampon trempé d'alcool et d'acétone, en proportion de 1:1.

Dans le cas de peintures très empâtées (2-3 mm. d'épaisseur) une fois que le fixage est terminé, on peut mettre comme poids un sac de sable sur les zones humides, en plaçant au préalable du papier à cigarettes au-dessous de ce sac.

Dans ce cas, un poids lourd ayant une surface plane ne conviendrait pas, parce qu'il pourrait entraîner des déformations de la couche picturale.

Le séchage définitif et la stabilisation de la pellicule se produisent dans dix jours.

Il n'est pas nécessaire d'enlever une pellicule invisible à l'oeil qui peut rester sur la surface de la peinture dans quelques endroits. Cette pellicule a une surface mate, elle est très élastique et ne peut causer aucun dégât à la couche picturale après un certain temps.

Une fois terminé le fixage de la couche picturale, les peintures exécutées sur papier peuvent être rentoilées, en vue de leur meilleure conservation sur des supports plus rigides: le carton, l'enduit sec.

Pour effecture l'opération de rentoilage on emploie le même AV-2EHA. A ce but on prend une dispersion à 20-25% et on l'applique au moyen d'un pinceau large et plat en couche

uniforme sur le support de doublage (carton, enduit sec, etc.) Quand on se sert comme support de doublage de l'enduit sec ou de quelque autre matériau dense et fortément encollé, il faut, une fois que la dispersion est appliquée, le mettre sous l'oeuvre et puis frotter celle-ci soigneusement avec la main, afin d'obtenir un collage complet, en couvrant au préalable le côté face avec du papier à cigarettes ou du papier à calquer.

Si pour le rentoilage on se sert de carton poreux, une fois que AV-2EHA est appliqué, l'eau s'infiltre rapidement dans le carton tandis que sur la surface reste un film déshydraté, ayant une surface inactive, sur laquelle rien ne peut être collé. Afin de "réanimer"la surface de ce film, de la rendre visqueuse à nouveau, on la traite par le mélange de dissolvants suivant: alcool - acétone en proportion 1:1. On applique ce mélange par un pinceau large et plat. On laisse la surface libre pendant quelque temps et puis on dépose l'oeuvre sur elle et on la frotte également avec beaucoup de soin.

Après le frottage, pour obtenir une adhésion parfaite, il faut mettre le poids (en forme d'un sac de sable, pour éviter les déformations éventuelles de la couche picturale). On recommande de placer le papier à cigarettes ou le papier à filtrer en plusieurs couches entre le poids et la surface peinte, et de le changer périodiquement jusq'au séchage complet.

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Action de trois traitements de désinfection sur des peaux de veau, mouton et chèvre tannées végétalement

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Après avoir étudié l'action de différents produits fongicides et insecticides sur des papiers de composition diverse, nous abordons dans cet article le problème du comportement du cuir utilisé en reliure lorsqu'il est soumis à ces mêmes traitements*.

Parmi les nombreux produits expérimentés sur les papiers, nous avons sélectionné, en fonction de leur activité biologique d'une part, et de leur innocuité vis-à-vis du papier d'autre part, les trois produits suivants (5-6-7) :

- l'oxyde d'éthylène,
- le formaldéhyde,
- le lindane.

Nous avons étudié uniquement le cas des peaux tannées végétalement, notre but étant de connaître le comportement des reliures en cuir et nous sommes limitées à l'examen des peaux avant teinture.

Pour effectuer un tel travail, il nous a fallu trouver auparavant une série d'examens permettant de contrôler la dégradation mécanique et chimique des cuirs. Nous avons voulu étudier également le comportement dans le temps des cuirs traités et avons pour cela mis au point différentes méthodes de vieillissement accéléré (1-3-8-12-13-15).

Nous exposons ici le protocole des expériences ainsi que les conclusions que nous pouvons en tirer.

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* Une première communication a déjà été présentée à ce sujet lors d'une réunion du Comité de Conservation : Action de l'aldéhyde formique et de l'oxyde d'éthylène sur la résistance physico-chimique des peaux de veau utilisées en reliure, rapport polytypé, ICOM, septembre 1969, 14 p., tabl.

I - CHOIX DES TESTS DE CONTROLE DE LA DEGRADATION DU CUIR

Parmi les nombreux essais de résistance mécanique et chimique des cuirs, nous en avons sélectionné plusieurs, les uns provenant des normes AFNOR* et I.U.P.**, les autres réalisés selon les indications de l'U.S.D.A.***.

A/ Examens mécaniques

- Résistance à la déchirure (norme I.U.P./8)
- Résistance à la traction (norme I.U.P./6)

Ces deux examens sont réalisés sur les deux sens de la peau.

- Résistance à l'éclatement (norme AFNOR NF Q 03.001)

B/ Examens chimiques

Tous les dosages sont réalisés à partir d'un cuir finement broyé. Les résultats présentant peu de dispersion, les chiffres indiqués sont la moyenne de deux essais.

Les mesures du taux d'humidité (norme AFNOR NF G 52.20 et de matières grasses (norme AFNOR NF G 52.204) reflètent le degré de desséèchement d'un cuir ; les autres examens chimiques permettent d'évaluer la détérioration des protéines. En fet, c'est l'augmentation progressive de l'acidité du cuir au c

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* A.F.N.O.R. = Association Française de Normalisation.
** I. U. P. = International Union Physical.
*** U. S. D. A. = United States Department of Agriculture.

du temps qui est un des facteurs principaux de sa dégradation. On pense qu'elle provient soit des produits utilisés en tannerie, soit d'une transformation interne de certains composants, soit encore d'une absorption de SO_2 dans une atmosphère polluée. De nombreux auteurs dont BEEBE, FREY et HANNIGAN pensent que l'acide sulfurique dégrade les protéines par hydrolyse accompagnée d'oxydation. L'hydrolyse provoquerait une rupture des chaînes peptidiques pouvant aller jusqu'à la libération d'acides aminés, tandis que l'oxydation conduirait à une dégradation totale donnant ainsi naissance à des sels d'ammonium solubles (1-4-8-9-10-11-16).

Ces produits de dégradation seront dosés dans l'extrait aqueux effectué à partir du cuir, selon la norme AFNOR NF G 52.205. On dosera en premier par distillation directe sur MgO les sels d'ammonium correspondant au stade final de la dégradation ; puis sur le distillat précédent, après minéralisation par la méthode Kjeldahl, les composés azotés, correspondant au premier degré de cette décomposition. La somme des deux résultats donne le taux d'azote soluble total (17).

La mesure du pH est réalisée selon le protocole indiqué par INNES (2). Le cuir est laissé en contact 24 heures avec l'eau distillée bouillie. Après décantation, on mesure le pH de l'extrait aqueux.

Par ailleurs, la mesure de l'indice de différence indique la nature des acides présents. Elle s'effectuera en faisant une dilution au dixième de l'extrait aqueux.BURTON (2) a formulé dans le tableau ci-dessous les différentes correspondances.

Indice de différ.	Valeurs initiales du pH		
	jusqu'à 2,9	2,9 - 3,0	plus de 3,0
0,7 ou plus	ac. forts prés. en quantité nuisible	indécis	des ac. forts peuvent être présents mais en petite quantité
0,6 - 0,7	acides forts présents ; en quantité nuisible éventuellement	indécis	acides forts absents
inférieur à 0,6	ac. forts abs. mais quantité indésirable d'ac. organiques probablement présents	ac. forts absents	ac. forts absents

Afin de connaître l'importance de la dispersion des essais mécaniques et chimiques, nous avons fait le bilan complet d'une peau de veau vierge (tableau n° 1).

Les éprouvettes ont été prélevées sur toute la surface de la peau, en dehors de la tête et des quatre pattes. Nous avons découpé quatre bandes égales dont les dimensions moyennes sont de 55 cm × 12 cm. Pour chacune des bandes, nous avons fait la moyenne des résultats de chaque test et nous les avons comparées entre elles (tableau n° 1).

Nous voyons qu'en ce qui concerne les tests mécaniques la dispersion est grande, alors qu'elle est moins importante pour les essais chimiques.

Pour tirer des conclusions valables quant à l'innocuité des traitements de désinfection sur nos peaux, il nous faudra faire appel pour les examens mécaniques aux calculs statistiques qui nous montreront si nos résultats sont ou non significatifs.

II - METHODES DE VIEILLISSEMENT ACCELERE ETUDIEES

Nous venons de voir que les deux facteurs principaux d'altération des cuirs sont l'hydrolyse et l'oxydation. Pour réaliser un vieillissement accéléré, il est donc nécessaire d'accentuer considérablement ces deux phénomènes. Plusieurs techniques nous sont offertes :

- les irradiations,
- la chaleur sèche,
- les oxydants.

Celles-ci ont été appliquées à un stock de peaux de veau tanné végétalement, les éprouvettes ayant été découpées selon les indications données ci-dessus pour la peau vierge.

1°/ Vieillissement accéléré par irradiation

A/ Les lampes à vapeur de mercure

Nous avons utilisé à cet effet des lampes germicides Mazda qui émettent des radiations ultraviolettes presque entièrement concentrées dans la bande 2537 Å . Ce sont des lampes à basse pression, se présentant sous forme de tube de 90 cm de longueur et 25 cm de diamètre, d'une puissance de 25 watts.

Dans un coffrage de bois très étanche, quatre lampes germicides ont été montées en parallèle à 10 cm les unes des autres. Les cuirs ont été placés à plat sous les lampes et à 10 cm de celles-ci. On a étudié sur chacune des faces l'effet produit par des temps d'exposition de 48 heures et d'une semaine

Après traitement, le cuir a très légèrement rougi (côté chair seulement) et a perdu de sa souplesse.

D'après le tableau 2, nous voyons que les pertes de résistance mécanique sont insignifiantes. Dans ces conditions, nous n'avons pas entrepris un bilan chimique complet, mais seulement le dosage du pH et celui des matières grasses; dans les deux cas il n'y a pas eu de modification.

B/ La lampe au xénon.

Nous avons utilisé un appareil allemand, le Xénotest, dont l'émetteur de radiations est un tube contenant une lampe au xénon à haute pression qui émet des radiations dans la gamme visible (400 à 700 millimicrons) et dans la gamme ultra-violette (300 à 400 millimicrons). Ces radiations sont assez voisines du spectre solaire.

L'appareil, en dehors de sa source lumineuse, est muni de nombreux perfectionnements : filtre anti-infra-rouge, qui évite un échauffement intense des éprouvettes, climatisation, pluie artificielle. Les échantillons de cuir sont disposés sur des tourniquets cylindriques tournant très lentement sur eux-mêmes et pivotant en même temps autour de la source lumineuse.

Nous avons opéré à la température constante de 35°C et à une humidité relative de 60 % (tableau 3). Les cuirs, exposés recto-verso pendant 2 jours, 3 jours, 4 jours, 5 jours, 6 jours ont rougi. La perte de la résistance mécanique étant infime, les examens chimiques n'ont pas été réalisés.

2°/ Vieillissement accéléré par la chaleur sèche

La méthode consiste à suspendre les cuirs dans une étuve ventilée. Nous avons étudié les effets causés par des durées d'exposition d'une semaine à 100°C (tableau 4), deux semaines à 100°C (tableau 5), deux semaines à 80°C (tableau 6), 150 jours à 50°C (tableau 7)*. On constate un rougissement assez important de toutes les peaux.

D'après les tableaux 4, 5, 6 et 7, nous voyons que la résistance mécanique des cuirs traités a diminué dans tous les cas, tandis que la résistance chimique est pratiquement identique sauf pour le vieillissement de 150 jours à 50°C.

Quels que soient la température et le temps de séjour dans l'étuve, on constate un affaiblissement considérable du taux de matières grasses. On peut penser que la chaleur provoquerait seulement une hydrolyse ménagée.

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* Les quatre temps d'exposition ont été faits sur quatre peaux différentes.

3°/ Vieillissement accéléré par les oxydants.

Trois méthodes ont été mises au point pour évaluer la résistance d'un cuir à l'action des oxydants.

- INNES utilise l'action du peroxyde en milieu sulfurique.
- KANAGY oxyde le cuir dans une bombe à oxygène à la chaleur
- BEEBE, FREY et HANNIGAN exposent le cuir dans une atmosphère contenant une forte proportion de SO_2 et SO_3.

Nous avons expérimenté au laboratoire uniquement la méthode de INNES (14) :

On dispose les bandes de cuir sur une plaque de verre (côté chair au-dessus) et on les humecte régulièrement avec de l'acide sulfurique à 5 % dans la proportion de 1 ml par gramme de cuir séché à l'air. Après une nuit à température ambiante, on ajoute, en l'étendant régulièrement, de l'eau oxygénée à 10 volumes à raison de 0,6 ml par gramme de cuir. On attend 24 heures, puis on applique cinq fois de suite toutes les 24 heures la même dose d'eau oxygénée.

Les cuirs ainsi traités ont rougi, se sont rétractés et ont durci. Certaines peaux présentent des altérations externes importantes, allant jusqu'au véritable trou.

Les essais mécaniques et chimiques ont été réalisés sur toutes les peaux, quel que soit leur état. Cependant, pour les analyses mécaniques, nous avons prélevé des éprouvettes sur des régions apparemment saines.

Pour les essais chimiques, toutes les peaux ont été utilisées dans leur intégralité. D'après le tableau 8, on note que les pertes physico-chimiques sont assez importantes. Le taux de matières grasses n'est pas modifié.

Dans un premier temps et pour notre présente étude, nous retiendrons deux techniques de vieillissement accéléré : le peroxyde et la chaleur sèche.

III - METHODES D'EXAMEN DES CUIRS TRAITES PAR LES PRODUITS DE DESINFECTION

1°/ Mode opératoire

Dans un premier temps, les peaux ont été traitées par chacun des trois produits à étudier et ont été vieillies artificiellement par la technique du peroxyde. Craignant que cette méthode de vieillissement accéléré soit peu homogène et peut-être trop agressive, nous avons répété les opérations en utilisant cette fois-ci la chaleur sèche (une semaine, étuve 100°C) comme source de vieillissement. Les essais de résistance chimique des peaux n'ont pas été réalisés dans ce cas, car nous avons pu observer, d'une part, que le vieillissement par la chaleur modifiait très peu cette résistance (voir tableau n° 4) et que, d'autre part, les peaux traitées et vieillies par le peroxyde n'avaient pas été altérées du point de vue chimique.

Ce travail a été effectué sur des lots de peaux de veau, de mouton et de chèvre tannées végétalement. Hormis quelques peaux de veau*, les autres peaux ont été découpées suivant la technique "des carrés latins" en 16 carrés égaux.

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* Comme nous l'avons signalé, les résultats des essais mécaniques obtenus sur ces peaux ainsi traitées étaient tellement dispersés que nous avons dû faire appel à l'analyse statistique pour l'interprétation. Or, les analyses ne peuvent être réalisées avec toute leur signification que si les éprouvettes sont découpées selon la technique "des carrés latins". Nous n'avons donc pas pu in corporer ces résultats dans les calculs ci-joints. C'est pourquoi nous les faisons figurer dans les tableaux 9-10-11 sans aucune interprétation.

2°/ Description des différentes techniques de désinfection

A. Le traitement par le formaldéhyde

L'aldéhyde formique est un produit utilisé pour son pouvoir fongique. Les échantillons ont été suspendus pendant 72 heures dans une étuve maintenue à 30°C et dans laquelle on a évaporé une quantité d'aldéhyde formique égale à 250 grammes par mètre cube. Parallèlement, afin d'éviter un dessèchement trop intense des cuirs, nous avons pulvérisé une quantité égale d'eau.

B. Le traitement par l'oxyde d'éthylène

Ce produit était connu pour son pouvoir insecticide. Nous avons déterminé il y a quelques années qu'il était également fongicide et bactéricide. Les échantillons ont été disposés dans un autoclave dans lequel on remplace l'air par de l'oxyde d'éthylène à une concentration de 550 grammes par mètre cube ; l'opération dure six heures et s'effectue à une température de 20°C.

C. Le traitement par le lindane (isomère gamma de l'hexachlorocyclohexane).

L'hexachlorocyclohexane $C_6H_6Cl_6$ se présente sous la forme d'une poudre blanche. Cependant, si l'HCH possède, grâce à l'isomère gamma, de grandes propriétés insecticides, il contient d'autres isomères (alpha, beta, delta) non insecticides et qui semblent nuisibles pour les documents graphiques, en particulier pour les métaux et dorures qu'ils oxydent. Pour cette raison, lorsqu'on désire utiliser l'HCH pour désinfecter les biens culturels, il est obligatoire de prendre l'isomère gamma pur, ou lindane.

Les cuirs ont été suspendus dans une chambre dans laquelle nous avons sublimé du lindane à raison de 1,5 g/m3.

IV - INTERPRETATION DES RESULTATS ET CONCLUSIONS

De l'ensemble de nos résultats (tableaux 9 à 13), il ressort que la résistance chimique des peaux examinées n'a pas été altérée par les traitements qu'on leur a fait subir.

En ce qui concerne les propriétés mécaniques, aucune action néfaste n'a été constatée sur les peaux de veau. Par contre, les traitements au lindane et au formaldéhyde semblent avoir affaibli la résistance mécanique des peaux de chèvre et de mouton. Nous pensons donc que, dans l'état actuel de nos recherches, l'oxyde d'éthylène peut être utilisé sans risque pour désinfecter les livres reliés avec les cuirs les plus couramment rencontrés. Le formaldéhyde et le lindane ayant affaibli la résistance mécanique de la chèvre et du mouton devraient être employés avec plus de prudence.

Nous n'avons pas étudié ici le cas des reliures en parchemin et le comportement de ce matériau pourrait faire l'objet d'un travail ultérieur.

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TABLEAU N° 1

BILAN DE LA RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU VIERGE

		Bande 1	Bande 2	Bande 3	Bande 4
Eclatement kg/mm		25,7	27,4	22,2	23,1
Déchirure kg/mm	ST	4,69	3,33	3,19	3,98
	SE	2,83	2,34	2,54	2,86
Traction kg/mm2	ST	1,72	1,86	1,97	1,79
	SE	3,84	3,62	3,06	3,11
Humidité %		9,6	9,7	9,7	9,1
pH		3,6	3,6	3,6	3,6
Dilution au 1/10e		4,3	4,3	4,3	4,3
Indice de différence		0,7	0,7	0,7	0,7
Azote soluble total * %		0,06	0,05	0,05	0,05

ST = sens travers SE : sens échine

* Les pourcentages sont calculés par rapport au cuir sec.

TABLEAU N° 2

RESISTANCE MECANIQUE ET CHIMIQUE DE LA PEAU DE VEAU APRES UN VIEILLISSEMENT ACCELERE PAR LES U.V.

		Cuir vierge	Cuir vieilli 48 heures sur chaque face	Cuir vieilli une semaine sur chaque face
Eclatement kg/mm		31,8	32,8	27,9
Déchirure kg/mm	ST	3,01	2,81	2,55
	SE	2,58	2,54	2,32
Traction kg/mm2	ST	2,32	2,17	2,21
	SE	2,46	2,69	2,34
Matières grasses %		5,0	5,2	
pH		3,5	3,5	
Dilution au 1/10e		4,0	4,0	
Indice de différence		0,5	0,5	

ST = sens travers SE = sens échine

TABLEAU N° 3

RESISTANCE MECANIQUE D'UNE PEAU DE VEAU APRES UN ESSAI DE VIEILLISSEMENT ACCELERE DE 2 JOURS, 3 JOURS, 4 JOURS, 5 JOURS ET 6 JOURS AU XENOTEST

		Cuir vierge	Cuir vieilli 2 j.	Cuir vieilli 3 j.	Cuir vieilli 4 j.	Cuir vieilli 5 j.	Cuir vieilli 6 j.
Eclatement kg/mm		23,5	23,3	21,7			27,1
Déchirure kg/mm	ST	3,78		4,35	4,84	3,15	2,49
	SE	3,73	3,97	2,83			
Traction kg/mm2	ST	2,17	2,39	2,04	1,98	1,94	2,32
	SE	2,47	2,16	2,45	2,43	2,42	2,58

ST = sens travers SE : sens échine

TABLEAU N° 4

RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU
APRES UN ESSAI DE VIEILLISSEMENT ACCELERE D'UNE SEMAINE A 100°C

		Cuir vierge	Cuir vieilli
Eclatement kg/mm		24,9	21,0
Déchirure kg/mm	ST	3,01	1,85
	SE	2,39	1,56
Traction kg/mm2	ST	1,89	1,59
	SE	2,40	1,84
Humidité %		8,9	7,5
Matières grasses* %		5,8	3,7
pH		3,6	3,2
Dilution au 1/10e		4,2	3,9
Indice de différence		0,6	0,7
Azote soluble total %*		0,05	0,04

ST = sens travers SE = sens échine

* Les pourcentages sont calculés par rapport au cuir sec et dégraissé.

TABLEAU N° 5

RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU
APRES UN ESSAI DE VIEILLISSEMENT ACCELERE DE 2 SEMAINES A 100°C

		Cuir vierge	Cuir vieilli
Eclatement kg/mm		28,4	23,7
Déchirure kg/mm	ST	3,63	2,27
	SE	3,24	2,01
Traction kg/mm2	ST	1,94	1,43
	SE	2,23	1,77
Humidité %		10,8	9,8
Matières grasses % *		6,4	3,8
pH		3,6	3,2
Dilution au 1/10e		4,3	4,0
Indice de différence		0,7	0,8
Azote soluble % (*)	(ammoniacal)	0,02	0,01
	(non ammoniacal)	0,02	0,04
	(total)	0,04	0,05

ST = sens travers SE = sens échine

(*) Les pourcentages sont calculés par rapport au cuir sec et dégraiss

TABLEAU N° 6

RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU
APRES UN ESSAI DE VIEILLISSEMENT ACCELERE DE 2 SEMAINES A 80°C

		Cuir vierge	Cuir vieilli
Eclatement kg/mm		25,4	22,7
Déchirure kg/mm	ST	3,30	2,59
	SE	3,08	2,45
Traction kg/mm2	ST	1,83	1,60
	SE	2,10	1,80
Humidité %		7,4	6,3
Matières grasses(1) %		5,6	4,5
pH		3,5	3,2
Dilution au 1/10e		4,2	3,9
Indice de différence		0,7	0,7
Azote soluble total* %		0,05	0,04

ST = sens travers SE = sens échine

*Les pourcentages sont calculés par rapport au cuir sec et dégraissé

TABLEAU N° 7

RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU
APRES UN ESSAI DE VIEILLISSEMENT ACCELERE DE 150 JOURS A 50°C

		Cuir vierge	Cuir vieilli
Eclatement kg/mm		23,7	20,2
Déchirure kg/mm	ST	2,36	1,52
	SE	2,08	1,33
Traction kg/mm2	ST	1,79	1,99
	SE	2,54	2,07
Humidité %		8,3	6,7
pH		3,5	3,1
Dilution au 1/10e		4,1	3,7
Indice de différence		0,6	0,6
Azote soluble total* %		0,05	0,12

ST = sens travers SE = sens échine

*Les pourcentages sont calculés par rapport au cuir sec.

TABLEAU N° 8

RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU APRES VIEILLISSEMENT ACCELERE PAR LE PEROXYDE D'HYDROGENE

		Cuir vierge	Cuir vieilli peroxyde
Eclatement kg/mm		24,3	13,7
Déchirure kg/mm	ST	3,79	1,95
	SE	2,73	1,87
Traction kg/mm2	ST	1,79	1,11
	SE	1,98	1,31
Humidité %		8,5	7,8
Matières grasses %		6	6
pH		3,5	1,8
Dilution au 1/10e		4,0	2,6
Indice de différence		0,5	0,8
Azote soluble % *	ammoniacal	0,03	0,10
	non ammoniacal	0,02	0,35
	total	0,05	0,45

ST = sens travers SE = sens échine

* Les pourcentages sont calculés par rapport au cuir sec et dégraissé.

TABLEAU N° 9

ACTION DE L'OXYDE D'ETHYLENE SUR LA RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU AVANT ET APRES VIEILLISSEMENT ACCELERE PAR LE PEROXYDE D'HYDROGENE

		Cuir vierge	Cuir vierge traité ox.éthy.	Cuir vieilli peroxyde	Cuir traité ox.éthyl. vieilli peroxyde
Eclatement kg/mm		26,3	27,5	15,8	18,9
Déchirure kg/mm	ST	3,58	2,64	1,54	1,82
	SE	3,01	2,26	1,68	1,85
Traction kg/mm2	ST	1,56	1,80	1,03	1,02
	SE	2,41	2,16	1,10	1,15
Humidité %		9,8	10,3	10,7	10,6
Matières grasses %		6,3	6,2	6,1	6,2
pH		3,4	3,5	1,9	1,9
Dilution au 1/10e		3,9	4,0	2,7	2,7
Indice de différence		0,5	0,5	0,8	0,8
Azote soluble % *	ammoniacal	0,02	0,02	0,12	0,13
	non ammoniacal	0,03	0,03	0,29	0,27
	total	0,05	0,05	0,41	0;40

ST = sens travers SE = sens échine

* Les pourcentages sont calculés par rapport au cuir sec et dégraissé.

TABLEAU N° 10

ACTION DU FORMALDEHYDE SUR LA RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU AVANT ET APRES VIEILLISSEMENT ACCELERE PAR LE PEROXYDE D'HYDROGENE

		Cuir vierge	Cuir vierge traité formal.	Cuir vieilli peroxyde	Cuir traité formal. vieilli peroxyde
Eclatement kg/mm		25,6	27,3	16,2	13,4
Déchirure kg/mm	ST	2,77	2,33	1,80	1,76
	SE	2,72	2,37	1,60	2,00
Traction	ST	2,06	1,97	1,16	1,47
	SE	2,31	1,99	1,56	1,34
Humidité %		8,2	8,9	8,5	8,0
Matières grasses %		5,9	6,0	5,4	5,2
pH		3,4	3,4	1,9	1,9
Dilution au 1/10e		4,0	4,0	2,8	2,8
Indice de différence		0,6	0,6	0,9	0,9
Azote soluble % *	ammoniacal	0,02	0,01	0,10	0,10
	non ammoniacal	0,03	0,03	0,57	0,51
	total	0,05	0,04	0,67	0,61

ST = sens travers SE = sens échine

* Les pourcentages sont calculés par rapport au cuir sec et dégraissé.

TABLEAU N° 11

ACTION DU LINDANE SUR LA RESISTANCE MECANIQUE ET CHIMIQUE D'UNE PEAU DE VEAU AVANT ET APRES VIEILLISSEMENT ACCELERE PAR LE PEROXYDE D'HYDROGENE

		Cuir vierge	Cuir vierge traité lindane	Cuir vieilli peroxyde	Cuir traité lindane vieilli peroxyde
Eclatement kg/mm		29,2	30,2	16,5	15,7
Déchirure kg/mm	ST	3,00	2,47	0,99	1,43
	SE	2,67	2,27	1,30	1,65
Traction kg/mm2	ST	1,95	1,99	1,06	1,07
	SE	2,22	2,44	1,16	0,84
Humidité %		11,3	11,4	13,0	12,9
Matières grasses %		6,3	6,0	5,7	6,3
pH		3,9	3,9	2,0	2,0
Dilution au 1/10e		4,5	4,5	2,8	2,8
Indice de différence		0,6	0,6	0,8	0,8
Azote soluble % *	(ammoniacal	0,03	0,03	0,15	0,15
	(non ammoniacal	0,02	0,03	1,04	1,03
	(total	0,05	0,06	1,19	1,18

ST = sens travers SE = sens échine

* Les pourcentages sont calculés par rapport au cuir sec et dégraissé.

TABLEAU N° 12

ACTION DES TROIS TRAITEMENTS DE DESINFECTION SUR LA RESISTANCE CHIMIQUE DE LA PEAU DE MOUTON AVANT ET APRES VIEILLISSEMENT ACCELERE PAR LE PEROXYDE D'HYDROGENE

	TRAITEMENT OX. D'ETHYLENE				TRAITEMENT FORMALDEHYDE				TRAITEMENT LINDANE			
	cuir vierge	cuir vierge traité	cuir vieilli peroxyde	cuir traité vieilli peroxyde	cuir vierge	cuir vierge traité	cuir vieilli peroxyde	cuir traité vieilli peroxyde	cuir vierge	cuir vierge traité	cuir vieilli peroxyde	cuir traité vieilli peroxyde
Humidité %	7;9	7,5	9,1	9	11,9	12	12	12	8,3	8,6	9,5	9,4
Matières grasses %	15	15,6	15	14,5	8,5	8,8	7,9	8,2	10,2	11,3	10,7	10,8
pH	3,8	3,8	1,9	1,9	3,3	3,2	1,8	1,8	3,4	3,4	1,8	1,8
Dilution au 1/10e	4,3	4,3	2,7	2;7	3,9	3,8	2,6	2,6	4,0	4,0	2,6	2,6
Indice de différence	0,5	0,5	0,8	0,8	0,6	0;6	0,8	0,8	0,6	0,6	0,8	0,8
Azote soluble % * (ammoniacal)	0,03	0,03	0,10	0,10	0,03	0,02	0,17	0,15	0,04	0,04	0,12	0,1
Azote soluble % * (non ammoniacal)	0,03	0,04	0,15	0,15	0,01	0,01	0,75	0,37	0,03	0,03	0,20	0,2
Azote soluble % * (total)	0;06	0,07	0,25	0,25	0,04	0,03	0,92	0,52	0,06	0,07	0,32	0,3

* Les pourcentages sont calculés par rapport au cuir sec et dégraissé.

TABLEAU N° 13

ACTION DES TROIS TRAITEMENTS DE DESINFECTION SUR LA RESISTANCE CHIMIQUE DE LA PEAU DE CHEVRE AVANT ET APRES VIEILLISSEMENT ACCELERE PAR LE PEROXYDE D'ETHYLENE

	TRAITEMENT OX. D'ETHYLENE				TRAITEMENT FORMALDEHYDE				TRAITEMENT LINDANE			
	cuir vierge	cuir vierge traité	cuir vieilli peroxyde	cuir traité vieilli peroxyde	cuir vierge	cuir vierge traité	cuir vieilli peroxyde	cuir traité vieilli peroxyde	cuir vierge	cuir vierge traité	cuir vieilli peroxyde	cuir traité vieilli
Humidité %	9,6	8,9	11,2	10,6	11,5	11,2	10	9,9	10,6	9,8	10,2	9,8
Matières grasses %	3,3	3,3	3,4	3,3	2,2	2,1	1,8	1,8	2,0	2,1	2,2	1,9
pH	4	4	1,8	1,8	3,9	3,8	1,6	1,6	3,9	3,9	1,8	1,8
Dilution au 1/10e	4,6	4,6	2,6	2,6	4,5	4,4	2,4	2,4	4,5	4,5	2,7	2,7
Indice de différence	0,6	0,6	0,8	0,8	0,6	0,6	0,8	0,8	0,6	0,6	0,9	0,9
Azote soluble % * (ammoniacal)	0,03	0,03	0,10	0,10	0,02	0,02	0,10	0,10	0,03	0,03	0,08	0,0
(non ammoniacal)	0,02	0,02	0,10	0,12	0,02	0,01	0,45	0,28	0,02	0,02	0,27	0,2
(total)	0,05	0,05	0,20	0,22	0,04	0,03	0,55	0,38	0,05	0,05	0,35	0,3

* Les pourcentages sont calculés par rapport au cuir sec et dégraissé.

PRESENTATION DES CALCULS STATISTIQUES CI-JOINTS

Données

Les données ayant servi aux calculs sont imprimées en début d'analyse, ceci afin de permettre un contrôle et un éventuel retour aux sources.

Chaque ligne représente une série de mesures ayant subi le même traitement. Les données sont divisées en blocs de 1, 2 ou 3 mesures. Chaque bloc représente un petit morceau de peau.

Quand il y avait plus de trois mesures (ou des mesures en nombre inégal), elles ont alors été remplacées par la moyenne des mesures pour des raisons de simplification de la programmation et parce que de toutes façons, l'orthogonalité multiple des tests en carrés latins est alors partiellement détruite.

Quand une mesure n'avait pu être faite par suite d'accident technique (traction perpendiculaire sur peau de veau n° 60, déchirure perpendiculaire sur peau de mouton n° 62), elle a été remplacée par une mesure fictive ayant pour valeur la moyenne des mesures réalisées sur le même petit morceau de peau.

Moyenne des pièces non traitées . Effet différentiel moyen

Afin de mieux présenter les résultats, les données sont ensuite centrées sur la moyenne des pièces non traitées. On ne mesurera ensuite que l'effet différentiel d'un traitement par rapport à l'absence de traitement.

Dans la première série de mesures, on compare donc le traitement soit à la peau vierge, soit à la peau vieillie.

Dans la deuxième série, on compare les trois traitements à la peau sans traitement.

Sur la ligne "Moyenne des pièces non traitées", on imprime la ou les deux moyennes de référence.

Sur la ligne "Effet différentiel moyen", on imprime la différence des moyennes entre une peau traitée et une peau non traitée.

Organisation des tests . I. Différence des moyennes

Le test le plus classique consiste à regarder si la différence des moyennes est significativement différente de ce que donnerait une répartition selon une loi de Gauss.

L'écart type de la différence des moyennes est égal à la somme harmonique des écarts-types de chaque moyenne. (Ces écarts types sont calculés sur la ligne "Ecart type des mesures").

Comme les écarts types sont mesurés avec un nombre relativement faible d'expériences, il serait normal de faire un test de Student (c'est-à-dire un test où l'on augmente l'incertitude de façon à tenir compte de la variabilité des écarts types mesurés). Afin de simplifier le test, nous avons préféré minorer l'écart type d'une des moyennes en le remplaçant par l'écart type résiduel* quand celui-ci était supérieur à l'écart type mesuré autour de cette moyenne.

$$\text{Ecart type } (m2 - M1) = \sqrt{\frac{\text{Max } (ET\ (m2),\ ER)^2 + \text{Max } (ETm1,\ ER)^2}{\text{nb de mesures}}}$$

Nous avons ensuite considéré que la différence des moyennes était "UN PEU" significative quand elle dépassait 2 écarts types et "BEAUCOUP" significative quand elle dépassait 3 écarts types. (Ce qui correspond à un risque de 5 % et de 1 ‰).

Il est à remarquer que ce test perd presque toute sa signification si les données individuelles sont remplacées par les moyennes, car les écarts types mesurés deviennent alors sujets à caution, tandis que l'écart type résiduel est nul. Ce test a alors été supprimé.

---

* L'écart type résiduel est la moyenne des écarts types internes à chaque petit carré.

Ces moyennes ainsi que les calculs suivants sont imprimés en dixième d'unité afin d'augmenter la précision des données.

Autres effets orthogonaux

Une propriété très intéressante des carrés latins est leur décomposition possible en n + 1 effets tous orthogonaux entre eux et ayant chacun n - 1 degrés de liberté (n étant la dimension du carré).

n^2 (nombre de degrés de liberté total) = 1 (moyenne générale) + (n + 1) (n - 1)

Mais ces séries de 5 répartitions orthogonales sont entièrement déterminées par deux d'entre elles. Aussi, si l'on désire tester l'effet vertical et l'effet horizontal, on est obligé d'utiliser les répartitions suivantes :

1 1 1 1	5 6 7 8	9 + - O	A D B C	W X Y Z
2 2 2 2	5 6 7 8	+ 9 O -	B C A D	Z Y X W
3 3 3 3	5 6 7 8	- O 9 +	C B D A	X W Z Y
4 4 4 4	5 6 7 8	O - + 9	D A C B	Y Z W X
Effet horizontal	Effet vertical	Effet diagonal	Effet 1	Effet 2

Hélas., les expériences n'ont pas été menées suivant une configuration (A,B,C,D) ou (W,X,Y,Z), mais selon des configurations variables selon les expériences.

Aussi, par permutation, nous avons confondu l'effet horizontal (ou effet ligne) avec l'effet des traitements.

L'effet horizontal initial est devenu effet vertical.

Les trois autres effets sont alors quelconques et dépendent de la configuration de chaque expérience.

Ainsi parmi les quatre effets orthogonaux testés, seul le premier a une signification réelle (l'effet dû à une homogénéité dans le sens perpendiculaire à l'échine), les trois autres étant des effets quelconques de référence.

II Effet maximum

En fait, on peut constater que l'écart type résiduel est souvent très inférieur aux écarts types entre les différents morceaux. Ceci est dû au fait que les peaux ont des résistances très différentes selon les parties considérées, et que ce phénomène vient interférer avec l'effet des produits testés. Afin de mettre en évidence ce phénomène, nous avons procédé à des calculs de variance expliquée et de variance résiduelle en décomposant la variance entre ses cinq effets orthogonaux principaux (ou 20 effets orthogonaux élémentaires). Cette variance expliquée étant égale à $(mij-\bar{\bar{m}})^2$, finalement nous avons jugé tout aussi simple et plus parlant de comparer les effets différentiels moyens, afin de voir s'ils étaient maxima ou non. La probabilité pour qu'un effet pris au hazard soit maximum est de 1/20 = 5 %, soit la même limite que pour le test précédent.

Nous avons donc calculé les trois effets maxima parmi les 20 effets étudiés. Chaque fois que les effets (maximum 1) ou (maximum 1 et maximum 2) ou (maximum 1 et maximum 2 et maximum 3) se retrouvent dans l'ordre parmi les effets des traitements, on peut considérer que ces effets sont significatifs à 5 % (c'est-à-dire que l'on a 5% de chance d'attribuer de la signification à un événement aléatoire).

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PEAU DE MOUTON 77 - TRAITEMENT AU FORMOL

ECLATEMENT

DONNEES

260 347 364	248 273 211	255 250 253	245 241 253
257 272 233	301 284 247	263 276 288	302 226 198
212 182 232	211 240 276	139 188 102	242 182 169
173 172 115	294 192 199	225 197 197	165 230 184

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		2666		1912		
EFFET DIFFERENTIEL MOYEN----->		0	-43	0	-34	-19
AUTRES EFFETS ORTHOGONAUX :		60	49	-94	-91	-19
		53	-61	-34	-34	-19
		199	0	57	-333	-19
		180	14	-86	-184	-19
ECART.TYPE DES MESURES		422	303	395	289	357
ECART TYPE RESIDUEL	362					
TEST EFFET MAXIMUM ?			NON		NON	
TEST EFFET SIGNIFICATIF ?			NON		NON	
(ECART-TYPE DES DIFFER DE MOY)		0	160	0	154	

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DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

382 422 541	525 522 434	587 450 420	350 391 319
440 447 529	336 412 426	445 427 431	250 374 310
200 259 163	288 253 268	230 339 166	99 118 173
216 344 206	276 397 263	193 237 294	197 237 208

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		4452		2129		
EFFET DIFFERENTIEL MOYEN----->		0	-429	0	427	0
AUTRES EFFETS ORTHOGONAUX :		167	376	225	-768	0
		-43	-8	52	0	0
		21	312	-307	-27	0
		-113	82	-134	165	0
ECART.TYPE DES MESURES		789	708	689	606	764
ECART TYPE RESIDUEL	654					
TEST EFFET MAXIMUM ?			NON		NON	
TEST EFFET SIGNIFICATIF ?			NON		NON	
(ECART-TYPE DES DIFFER DE MOY)		0	306	0	274	

****

DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

347 399 449	473 450 402	364 426 376	377 368 427
296 386 497	419 336 271	385 348 340	375 277 371
230 300 205	231 244 142	232 95 189	234 166 103
216 226 274	303 338 208	154 158 203	208 217 198

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		4047		1975		
EFFET DIFFERENTIEL MOYEN----->		1	-462	0	277	-45
AUTRES EFFETS ORTHOGONAUX :		176	169	-286	-243	-45
		-211	-29	-76	133	-45
		5	-23	-137	-27	-45
		-219	119	-168	85	-45
ECART.TYPE DES MESURES		382	604	584	522	593
ECART TYPE RESIDUEL	606					
TEST EFFET MAXIMUM ?			MAXIMUM1		NON	
TEST EFFET SIGNIFICATIF ?			NON		NON	
(ECART-TYPE DES DIFFER DE MOY)		0	247	0	247	

****

TRACTION DANS LE SENS TRANSVERSAL

DONNEES (MOYENNES SEULEMENT)

211	171	202	174
211	160	157	115
86	80	68	61
65	67	78	75

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		1895		737		
EFFET DIFFERENTIEL MOYEN----->		0	-287	0	-24	-77
AUTRES EFFETS ORTHOGONAUX :		116	-121	-53	-253	-77
		-31	-126	-13	-141	-77
		-76	104	-71	-268	-77
		-106	-93	-96	-16	-77
ECART.TYPE DES MESURES		173	340	98	54	233
ECART TYPE RESIDUEL	0					
TEST EFFET MAXIMUM ?			MAXIMUM1		NON	

****

TRACTION DANS LE SENS DE L'ECHINE

DONNEES (MOYENNES SEULEMENT)

295	189	227	116
202	266	226	94
119	130	96	54
114	128	136	66

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		2067		997		
EFFET DIFFERENTIEL MOYEN----->		0	-97	0	113	4
AUTRES EFFETS ORTHOGONAUX :		293	250	180	-707	4
		275	-67	-79	-112	4
		225	30	60	-299	4
		105	-32	120	-177	4
ECART.TYPE DES MESURES		647	637	291	271	501
ECART TYPE RESIDUEL						
TEST EFFET MAXIMUM ?			NON		NON	

****
PEAU DE MOUTON 62 - TRAITEMENT AU LINDANE
ECLATEMENT
DONNEES (MOYENNES SEULEMENT)

186	239	197	233
137	239	212	206
92	135	148	138
139	145	187	174

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	2137		1282		
EFFET DIFFERENTIEL MOYEN----->	0	-152	0	330	44
AUTRES EFFETS ORTHOGONAUX :	-324	185	150	168	44
	158	88	43	-109	44
	-7	-102	168	120	44
	75	83	73	-52	44
ECART.TYPE DES MESURES	226	376	214	199	317
ECART TYPE RESIDUEL	0				
TEST EFFET MAXIMUM ?		NON		MAXIMUM1	

****
DECHIRURE DANS LE SENS TRANSVERSAL
DONNEES

472 455	423 346	474 555	349 389
475 400	522 445	345 383	290 274
239 177	395 385	375 376	271 195
253 398	394 350	267 319	154 139

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	4328		3016		
EFFET DIFFERENTIEL MOYEN----->	0	-410	0	-173	-145
AUTRES EFFETS ORTHOGONAUX :	-85	403	195	-1095	-145
	0	-50	-302	-230	-145
	-90	49	-288	-253	-145
	-100	-914	219	213	-145
ECART.TYPE DES MESURES	663	816	854	934	840
ECART TYPE RESIDUEL	385				
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?		NON		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	371	0	447	

****
DECHIRURE DANS LE SENS DE L'ECHINE
DONNEES

355 403	326 356	322 311	400 376
325 291	407 314	322 368	290 362
181 164	231 170	147 131	165 167
198 217	147 187	181 191	150 242

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	3561		1695		
EFFET DIFFERENTIEL MOYEN----->	0	-212	0	196	-3
AUTRES EFFETS ORTHOGONAUX :	39	44	-161	62	-3
	58	224	-125	-173	-3
	14	-75	139	-94	-3
	100	8	-1	-123	-3
ECART.TYPE DES MESURES	328	381	272	296	353
ECART TYPE RESIDUEL	289				
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?		NON		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	177	0	146	

****
TRACTION DANS LE SENS TRANSVERSAL
DONNEES (MOYENNES SEULEMENT)

158	122	132	130
106	141	140	122
139	88	89	92
63	86	104	74

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1355		1020		
EFFET DIFFERENTIEL MOYEN----->	0	-82	0	-202	-71
AUTRES EFFETS ORTHOGONAUX :	-22	-95	-25	-142	-71
	-32	-135	-127	10	-71
	2	-187	97	-197	-71
	-7	0	-117	-160	-71
ECART.TYPE DES MESURES	135	144	214	152	184
ECART TYPE RESIDUEL	0				
TEST EFFET MAXIMUM ?		NON		MAXIMUM1	

****
TRACTION DANS LE SENS DE L'ECHINE
DONNEES (MOYENNES SEULEMENT)

175	188	217	102
113	195	192	137
105	148	131	78
118	134	146	78

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1705		1155		
EFFET DIFFERENTIEL MOYEN----->	0	-112	0	35	-19
AUTRES EFFETS ORTHOGONAUX :	-152	232	285	-442	-19
	17	-30	-117	52	-19
	17	-40	-60	5	-19
	85	-22	90	-230	-19
ECART.TYPE DES MESURES	423	353	265	256	336
ECART TYPE RESIDUEL	0				
TEST EFFET MAXIMUM ?		NON		NON	

****

PEAU DE MOUTON 92 - TRAITEMENT A L'OXYDE D'ETHYLENE

ECLATEMENT

DONNEES

148 187	140 171	227 191	195 183
68 85	206 174	131 135	164 151
134 138	154 126	195 143	102 81
200 178	204 164	152 119	122 81

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1813		1341		
EFFET DIFFERENTIEL MOYEN----->	0	-420	0	184	-58
AUTRES EFFETS ORTHOGONAUX :	-154	108	39	-228	-58
	-7	50	-418	139	-58
	-137	-259	49	111	-58
	-75	-250	121	-30	-58
ECART.TYPE DES MESURES	241	426	318	400	417
ECART TYPE RESIDUEL	179				
TEST EFFET MAXIMUM ?		MAXIMUM1		NON	
TEST EFFET SIGNIFICATIF ?		UN.PEU		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	173	0	187	

****

DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

376 375 365	362 360 386	327 371 375	357 353 334
442 480 444	343 324 345	275 271 252	292 327 315
246 224 214	219 217 284	291 264 316	208 298 256
324 264 277	252 222 273	316 232 351	203 232 195

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	3617		2530		
EFFET DIFFERENTIEL MOYEN----->	0	-192	0	87	-25
AUTRES EFFETS ORTHOGONAUX :	285	-84	-39	-265	-25
	-49	-217	372	-208	-25
	-221	84	-41	74	-25
	-16	-390	19	283	-25
ECART.TYPE DES MESURES	166	712	358	469	481
ECART TYPE RESIDUEL	316				
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?		NON		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	224	0	170	

****

DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

378 360 372	441 366 353	374 354 405	378 391 372
370 375 280	370 690 338	365 287 350	259 231 348
290 156 216	149 261 269	204 286 230	257 288 273
246 283 215	149 282 308	209 266 302	221 308 276

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	3786		2398		
EFFET DIFFERENTIEL MOYEN----->	0	-233	1	156	-18
AUTRES EFFETS ORTHOGONAUX :	-141	221	-65	-90	-18
	268	-120	58	-282	-18
	-34	-57	223	-207	-18
	-255	-67	318	-71	-18
ECART.TYPE DES MESURES	234	1111	473	466	672
ECART TYPE RESIDUEL	786				
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?		NON		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	392	0	320	

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TRACTION DANS LE SENS TRANSVERSAL

DONNEES (MOYENNES SEULEMENT)

153	102	101	102
109	109	114	74
81	53	74	79
85	73	76	32

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1145		717		
EFFET DIFFERENTIEL MOYEN----->	0	-130	0	-52	-45
AUTRES EFFETS ORTHOGONAUX :	139	-88	-18	-213	-45
	-11	-46	-16	-108	-45
	116	-193	-11	-93	-45
	-41	-108	4	-36	-45
ECART.TYPE DES MESURES	222	160	111	204	187
ECART TYPE RESIDUEL	0				
TEST EFFET MAXIMUM ?		NON		NON	

****

TRACTION DANS LE SENS DE L'ECHINE

DONNEES (MOYENNES SEULEMENT)

157	94	135	59
67	174	124	91
86	48	123	51
195	110	64	80

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1112		770		
EFFET DIFFERENTIEL MOYEN----->	0	28	0	352	95
AUTRES EFFETS ORTHOGONAUX :	321	124	174	-238	95
	394	124	-251	114	95
	164	-116	16	316	95
	-41	19	446	-43	95
ECART.TYPE DES MESURES	376	401	304	505	430
ECART TYPE RESIDUEL	0				
TEST EFFET MAXIMUM ?		NON		NON	

****

PEAU DE CHEVRE 90 - TRAITEMENT AU FORMOL

ECLATEMENT

DONNEES

303 329	319 319	355 365	338 292
276 280	342 365	325 356	346 354
272 250	268 281	180 239	223 59
131 139	184 174	329 243	209 86

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		3275		2215		
EFFET DIFFERENTIEL MOYEN----->		0	30	0	-346	-79
AUTRES EFFETS ORTHOGONAUX :		-270	70	245	-361	-79
		-178	-82	-185	130	-79
		-303	-95	293	-211	-79
		321	-75	-271	-291	-79
ECART.TYPE DES MESURES		231	322	684	703	551
ECART TYPE RESIDUEL	369					
TEST EFFET MAXIMUM ?			NON		NON	
TEST EFFET SIGNIFICATIF ?			NON		NON	
(ECART-TYPE DES DIFFER DE MOY)		0	184	0	346	

****

DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

214 314 247	260 278 273	330 346 321	256 244 360
280 303 268	244 260 267	177 298 336	255 253 339
187 186 161	130 78 114	249 145 144	262 139 103
241 177 235	193 121 180	168 178 173	204 180 227

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		2868		1581		
EFFET DIFFERENTIEL MOYEN----->		1	-134	0	316	45
AUTRES EFFETS ORTHOGONAUX :		119	-226	163	127	45
		21	-19	13	168	45
		-71	93	12	149	45
		-172	81	213	61	45
ECART.TYPE DES MESURES		440	417	529	319	463
ECART TYPE RESIDUEL	528					
TEST EFFET MAXIMUM ?			NON		MAXIMUM1	
TEST EFFET SIGNIFICATIF ?			NON		NON	
(ECART-TYPE DES DIFFER DE MOY)		0	215	0	215	

****

DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

308 250 290	317 292 325	269 274 290	244 275 271
350 278 199	278 325 300	268 255 330	232 294 252
123 101 90	134 241 208	220 252 218	194 216 172
220 209 160	147 248 249	169 204 187	174 262 188

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		2837		1807		
EFFET DIFFERENTIEL MOYEN----->		0	-36	0	207	43
AUTRES EFFETS ORTHOGONAUX :		-173	231	124	-10	43
		232	23	97	-181	43
		117	67	-182	170	43
		-14	-51	100	137	43
ECART.TYPE DES MESURES		238	412	532	358	410
ECART TYPE RESIDUEL	439					
TEST EFFET MAXIMUM ?			NON		NON	
TEST EFFET SIGNIFICATIF ?			NON		NON	
(ECART-TYPE DES DIFFER DE MOY)		0	179	0	199	

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TRACTION DANS LE SENS TRANSVERSAL

DONNEES (MOYENNES SEULEMENT)

250	205	211	205
210	207	208	170
112	123	113	94
108	107	101	109

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		2177		1105		
EFFET DIFFERENTIEL MOYEN----->		0	-189	0	-42	-57
AUTRES EFFETS ORTHOGONAUX :		59	-36	-58	-196	-57
		56	-31	-116	-141	-57
		6	-8	-78	-151	-57
		-31	-56	-91	-53	-57
ECART.TYPE DES MESURES		187	166	104	31	157
ECART TYPE RESIDUEL	0					
TEST EFFET MAXIMUM ?			NON		NON	

****

TRACTION DANS LE SENS DE L'ECHINE

DONNEES (MOYENNES SEULEMENT)

261	264	297	205
243	288	257	246
152	220	127	141
121	152	144	144

		VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES		2567		1600		
EFFET DIFFERENTIEL MOYEN----->		0	18	0	-197	-44
AUTRES EFFETS ORTHOGONAUX :		-141	226	-21	-243	-44
		-33	-76	-103	34	-44
		-56	176	-111	-188	-44
		94	-41	34	-266	-44
ECART.TYPE DES MESURES		330	178	357	115	279
ECART TYPE RESIDUEL	0					
TEST EFFET MAXIMUM ?			NON		NON	

****

PEAU DE CHEVRE 101 - TRAITEMENT AU LINDANE

ECLATEMENT

DONNEES

301 349 351	226 302 280	318 354 358	330 334 316
274 214 216	252 276 278	227 313 378	359 209 284
141 114 108	133 121 170	205 249 192	182 235 250
125 182 157	214 176 161	192 81 119	139 235 204

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	3182		1749		
EFFET DIFFERENTIEL MOYEN----->	0	-448	1	-94	-135
AUTRES EFFETS ORTHOGONAUX :	-355	-308	22	98	-135
	60	-143	-323	-135	-135
	148	-185	-348	-157	-135
	-241	-243	7	-64	-135
	362	528	500	423	494
ECART.TYPE DES MESURES	504				
ECART TYPE RESIDUEL		MAXIMUM1		NON	
TEST EFFET MAXIMUM ?		UN.PEU		NON	
TEST EFFET SIGNIFICATIF ?					
(ECART-TYPE DES DIFFER DE MOY)	0	210	0	205	

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DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

279 294 288	380 293 312	415 342 328	331 335 342
202 201 220	322 314 348	394 366 282	275 337 294
187 185 239	253 233 210	217 359 155	235 276 319
224 296 176	204 242 254	215 238 215	218 334 253

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	3282		2389		
EFFET DIFFERENTIEL MOYEN----->	0	-319	1	1	-79
AUTRES EFFETS ORTHOGONAUX :	-509	-31	102	122	-79
	-18	32	-247	-83	-79
	25	-161	-109	-70	-79
	-226	33	160	-283	-79
	380	606	550	405	514
ECART.TYPE DES MESURES	498				
ECART TYPE RESIDUEL		NON		NON	
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?					
(ECART-TYPE DES DIFFER DE MOY)	0	226	0	214	

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DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

271 264 308	286 280 250	314 344 353	238 250 276
275 278 286	360 352 323	302 267 274	258 262 260
217 244 165	241 222 277	242 216 208	217 226 222
197 212 185	186 203 240	304 252 243	134 155 141

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	2861		2247		
EFFET DIFFERENTIEL MOYEN----->	0	53	0	-203	-37
AUTRES EFFETS ORTHOGONAUX :	-135	129	211	-354	-37
	-75	-103	45	-15	-37
	-70	-37	132	-174	-37
	81	-291	200	-139	-37
	351	339	253	475	377
ECART.TYPE DES MESURES	235				
ECART TYPE RESIDUEL		NON		NON	
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?					
(ECART-TYPE DES DIFFER DE MOY)	0	140	0	155	

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TRACTION DANS LE SENS TRANSVERSAL

DONNEES (MOYENNES SEULEMENT)

180	205	185	133
184	214	165	161
132	117	111	150
134	120	108	121

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1757		1275		
EFFET DIFFERENTIEL MOYEN----->	0	53	0	-142	-22
AUTRES EFFETS ORTHOGONAUX :	-16	124	-93	-103	-22
	49	-218	101	-21	-22
	21	1	-48	-63	-22
	-101	41	116	-146	-22
	263	209	150	73	201
ECART.TYPE DES MESURES	0				
ECART TYPE RESIDUEL		NON		NON	
TEST EFFET MAXIMUM ?					

****

TRACTION DANS LE SENS DE L'ECHINE

DONNEES (MOYENNES SEULEMENT)

162	197	189	213
189	212	191	155
71	160	180	122
94	162	182	173

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1902		1332		
EFFET DIFFERENTIEL MOYEN----->	0	-34	0	195	40
AUTRES EFFETS ORTHOGONAUX :	-327	210	238	40	40
	200	28	108	-174	40
	-24	160	78	-52	40
	30	-37	-74	243	40
	164	204	415	346	316
ECART.TYPE DES MESURES	0				
ECART TYPE RESIDUEL		NON		NON	
TEST EFFET MAXIMUM ?					

****

PEAU DE CHEVRE 81 - TRAITEMENT A L'OXYDE D'ETHYLENE

ECLATEMENT

DONNEES

144 153	236 221	252 278	250 306
245 233	234 221	249 241	236 230
121 109	69 187	116 186	163 207
63 136	73 160	96 183	166 166

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	2300		1447		
EFFET DIFFERENTIEL MOYEN----->	0	61	0	-143	-20
AUTRES EFFETS ORTHOGONAUX :	-368	-122	127	281	-20
	-141	2	106	-49	-20
	-136	121	26	-93	-20
	-251	12	69	87	-20
ECART.TYPE DES MESURES	529	82	448	436	418
ECART TYPE RESIDUEL	327				
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?		NON		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	219	0	221	

****

DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

255 322 228	263 258 236	262 265 262	300 255 329
281 261 334	253 262 259	241 272 280	234 243 228
188 266 217	184 199 226	161 214 155	191 191 175
104 107 173	164 212 108	167 221 169	210 186 222

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	2695		1972		
EFFET DIFFERENTIEL MOYEN----->	0	-71	0	-252	-80
AUTRES EFFETS ORTHOGONAUX :	-53	-146	-92	-30	-80
	-61	-108	-27	-126	-80
	-134	76	88	-353	-80
	-86	32	-246	-21	-80
ECART.TYPE DES MESURES	299	270	290	422	342
ECART TYPE RESIDUEL	318				
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?		NON		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	129	0	152	

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DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

256 280 228	231 257 216	234 235 242	234 281 217
323 256 291	246 216 225	238 242 326	232 321 264
231 231 191	210 210 258	202 165 199	153 142 182
224 193 161	134 133 187	248 183 229	194 220 224

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	2425		1978		
EFFET DIFFERENTIEL MOYEN----->	0	225	0	-36	47
AUTRES EFFETS ORTHOGONAUX :	186	-99	84	18	47
	11	126	57	-5	47
	-117	212	75	19	47
	231	132	-157	-16	47
ECART.TYPE DES MESURES	207	383	324	355	341
ECART TYPE RESIDUEL	327				
TEST EFFET MAXIMUM ?		NON		NON	
TEST EFFET SIGNIFICATIF ?		NON		NON	
(ECART-TYPE DES DIFFER DE MOY)	0	145	0	139	

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TRACTION DANS LE SENS TRANSVERSAL

DONNEES (MOYENNES SEULEMENT)

167	121	134	183
141	138	127	146
94	99	102	116
79	81	96	116

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	1512		1027		
EFFET DIFFERENTIEL MOYEN----->	0	-132	0	-97	-57
AUTRES EFFETS ORTHOGONAUX :	-67	-172	-122	133	-57
	38	-49	-84	-132	-57
	-42	-44	8	-149	-57
	0	-124	-102	-2	-57
ECART.TYPE DES MESURES	248	69	81	148	165
ECART TYPE RESIDUEL	0				
TEST EFFET MAXIMUM ?		NON		NON	

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TRACTION DANS LE SENS DE L'ECHINE

DONNEES (MOYENNES SEULEMENT)

191	230	184	226
183	206	287	183
128	164	166	149
106	141	174	139

	VIERGE	TRAITEE	VIEILLIE	TRAITEE	TOTAL
MOYENNE DES PIECES NON TRAITES	2077		1517		
EFFET DIFFERENTIEL MOYEN----->	0	70	0	-117	-11
AUTRES EFFETS ORTHOGONAUX :	-277	55	230	-54	-11
	-42	160	43	-207	-11
	123	-122	38	-84	-11
	-17	163	-184	-7	-11
ECART.TYPE DES MESURES	204	427	152	240	284
ECART TYPE RESIDUEL	0				
TEST EFFET MAXIMUM ?		NON		NON	

PEAU DE VEAU 67 - VIERGE
ECLATEMENT
DONNEES

262 223	315 360	359 353	281 240
316 326	255 341	292 286	260 286
341 323	316 350	311 328	283 272
200 273	328 334	293 291	292 291

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	2991				
EFFET DIFFERENTIEL MOYEN----->	0	-38	164	-113	3
AUTRES EFFETS ORTHOGONAUX :	-161	257	150	-234	3
	-112	-193	79	239	3
	-141	262	-34	-74	3
	-139	134	-71	89	3
ECART.TYPE DES MESURES	517	285	250	383	387
ECART TYPE RESIDUEL 229					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	208	203	227	

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DECHIRURE DANS LE SENS TRANSVERSAL
DONNEES

430 355 388	302 275 262	252 266 288	236 280 254
355 375 451	321 312 400	264 259 271	167 182 208
400 379 421	258 252 290	371 400 407	232 234 259
353 348 415	232 278 231	270 291 304	224 266 225

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	2989				
EFFET DIFFERENTIEL MOYEN----->	0	-18	263	-124	30
AUTRES EFFETS ORTHOGONAUX :	902	-144	46	-683	30
	426	-89	19	-235	30
	-128	-70	234	86	30
	-159	-32	77	236	30
ECART.TYPE DES MESURES	576	845	733	574	706
ECART TYPE RESIDUEL 306					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	295	269	234	

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DECHIRURE DANS LE SENS DE L'ECHINE
DONNEES

316 271 364	228 198 262	292 260 267	204 220 216
211 251 246	195 255 224	202 228 252	218 228 316
315 313 343	276 253 350	191 268 201	212 257 213
311 370 485	228 222 276	210 209 252	207 277 222

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	2581				
EFFET DIFFERENTIEL MOYEN----->	0	-226	79	143	0
AUTRES EFFETS ORTHOGONAUX :	582	-108	-221	-256	0
	-88	224	-290	150	0
	-46	12	-117	149	0
	138	-41	203	-302	0
ECART.TYPE DES MESURES	471	308	528	795	571
ECART TYPE RESIDUEL 424					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	182	204	266	

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TRACTION DANS LE SENS TRANSVERSAL
DONNEES

177 176 172	146 141 145	196 198 226	204 210 226
145 139 140	138 152 136	164 160 159	238 233 240
238 237 202	171 173 150	179 172 168	116 111 173
200 140 117	154 140 164	170 152 163	176 210 204

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	1847				
EFFET DIFFERENTIEL MOYEN----->	0	-143	-105	-188	-109
AUTRES EFFETS ORTHOGONAUX :	-111	-338	-91	103	-109
	-130	-118	-396	208	-109
	-292	-73	9	-81	-109
	-1	-28	-261	-146	-109
ECART.TYPE DES MESURES	288	395	374	270	343
ECART TYPE RESIDUEL 193					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	141	136	113	

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TRACTION DANS LE SENS DE L'ECHINE
DONNEES

301 257 232	264 210 269	215 227 295	173 161 189
254 274 337	279 284 264	227 216 262	153 138 133
312 253 291	278 285 291	234 234 302	134 93 78
237 236 179	298 280 246	254 243 279	169 148 182

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	2327				
EFFET DIFFERENTIEL MOYEN----->	0	23	-6	-34	-4
AUTRES EFFETS ORTHOGONAUX :	308	379	163	-867	-4
	78	-48	-86	40	-4
	-140	135	158	-169	-4
	43	8	-226	158	-4
ECART.TYPE DES MESURES	436	613	797	465	596
ECART TYPE RESIDUEL 307					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	217	262	184	

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PEAU DE VEAU 60 - VIEILLIE A LA CHALEUR

ECLATEMENT

DONNEES

167 209	267 253	244 250	284 298
231 252	288 217	216 227	295 230
311 331	231 223	263 258	237 263
237 149	260 256	210 258	301 279

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	2465				
EFFET DIFFERENTIEL MOYEN----->	0	-20	181	-65	24
AUTRES EFFETS ORTHOGONAUX :	-143	28	-57	268	24
	12	-171	-1	256	24
	-171	48	281	-62	24
	-186	266	-146	162	24
ECART.TYPE DES MESURES	391	290	357	454	389
ECART TYPE RESIDUEL	212				
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	172	187	211	

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DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

310 203 184	176 167 160	292 230 246	159 181 158
175 159 251	215 192 189	154 168 202	150 174 177
193 200 227	254 167 190	298 189 226	272 150 160
188 196 181	171 169 151	156 173 161	139 157 158

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	2054				
EFFET DIFFERENTIEL MOYEN----->	1	-207	51	-387	-135
AUTRES EFFETS ORTHOGONAUX :	10	-219	25	-358	-135
	-4	-222	-245	-70	-135
	-142	-30	-217	-152	-135
	-138	-303	38	-139	-135
ECART.TYPE DES MESURES	504	295	440	155	412
ECART TYPE RESIDUEL	440				
TEST EFFET MAXIMUM ?		NON	NON	MAXIMUM1	
TEST EFFET SIGNIFICATIF ?		NON	NON	UN.PEU	
(ECART-TYPE DES DIFFER DE MOY)	0	193	193	193	

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DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

180 230 219	190 166 206	168 189 185	208 222 158
168 250 243	220 202 234	125 164 133	168 159 174
208 213 213	177 175 195	203 190 212	162 157 159
233 215 314	141 158 158	163 156 152	178 149 205

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	1950				
EFFET DIFFERENTIEL MOYEN----->	0	-83	-63	-98	-61
AUTRES EFFETS ORTHOGONAUX :	288	-98	-233	-200	-61
	68	-17	-140	-155	-61
	-295	-31	7	75	-61
	-160	-158	98	-24	-61
ECART.TYPE DES MESURES	213	404	209	477	348
ECART TYPE RESIDUEL	262				
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	139	106	157	

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TRACTION DANS LE SENS TRANSVERSAL

DONNEES

140 102 86	154 191 197	190 186 186	124 193 170
178 171 159	77 97 125	157 150 153	184 209 202
160 165 174	139 158 154	130 114 132	176 211 215
190 224 228	146 150 158	157 143 152	180 172 151

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	1598				
EFFET DIFFERENTIEL MOYEN----->	1	-63	8	111	14
AUTRES EFFETS ORTHOGONAUX :	49	-159	-56	224	14
	-359	102	155	160	14
	-61	88	-167	197	14
	-76	72	139	-77	14
ECART.TYPE DES MESURES	369	394	294	281	343
ECART TYPE RESIDUEL	210				
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	155	136	133	

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TRACTION DANS LE SENS DE L'ECHINE

DONNEES

169 196 140	200 205 214	250 270 260	167 153 161
182 202 225	245 254 236	227 230 254	137 134 131
180 157 200	208 208 171	215 195 260	161 153 180
152 124 104	213 192 132	256 240 260	177 167 187

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	1987				
EFFET DIFFERENTIEL MOYEN----->	0	60	-80	-108	-32
AUTRES EFFETS ORTHOGONAUX :	-294	119	443	-397	-32
	47	-187	78	-65	-32
	-72	102	103	-261	-32
	-112	11	3	-31	-32
ECART.TYPE DES MESURES	414	452	290	467	417
ECART TYPE RESIDUEL	187				
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	176	145	180	

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 PEAU DE CHEVRE 109 - VIERGE
ECLATEMENT
DONNEES
 237 241        226 344        245 260        325 234
 233 237        283 279        314 239        274 298
 235 285        247 298        304 289        255 330
 200 224        292 310        283 327        353 298
                                     RIEN    FORMOL   LINDANE OX.ETHYLN     TOTAL
MOYENNE DES PIECES NON TRAITES       2640
EFFET DIFFERENTIEL MOYEN----->          0       56       163       218       109
AUTRES EFFETS ORTHOGONAUX :          -275      208       186       318       109
                                      215      -38       153       108       109
                                      132       73       173        58       109
                                      116      227       -45       140       109
ECART.TYPE DES MESURES                419      282       300       476       388
ECART TYPE RESIDUEL            326
TEST EFFET MAXIMUM ?                           NON       NON       NON
TEST EFFET SIGNIFICATIF ?                      NON       NON       NON
(ECART-TYPE DES DIFFER DE MOY)          0      187       187       224
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DECHIRURE DANS LE SENS TRANSVERSAL
DONNEES
 348 289 271    275 307 280    295 253 315    222 266 250
 246 240 243    290 332 350    251 254 294    205 225 242
 283 293 287    294 396 334    346 420 452    169 163 346
 278 278 259    322 212 280    220 323 310    238 280 391
                                     RIEN    FORMOL   LINDANE OX.ETHYLN     TOTAL
MOYENNE DES PIECES NON TRAITES       2808
EFFET DIFFERENTIEL MOYEN----->          1     -164       344        17        49
AUTRES EFFETS ORTHOGONAUX :           -45      252       302      -310        49
                                      531        5      -206      -131        49
                                     -142      129        47       164        49
                                       72       52       -34       107        49
ECART.TYPE DES MESURES                318      415       845       476       581
ECART TYPE RESIDUEL            526
TEST EFFET MAXIMUM ?                           NON       NON       NON
TEST EFFET SIGNIFICATIF ?                      NON       NON       NON
(ECART-TYPE DES DIFFER DE MOY)          0      214       287       214
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DECHIRURE DANS LE SENS DE L'ECHINE
DONNEES
 236 238 250    221 260 225    256 257 252    148 254 254
 226 200 257    222 303 290    303 199 246    214 230 189
 230 262 286    283 340 314    236 277 249    203 230 219
 330 301 238    253 188 300    212 287 303    253 260 260
                                     RIEN    FORMOL   LINDANE OX.ETHYLN     TOTAL
MOYENNE DES PIECES NON TRAITES       2375
EFFET DIFFERENTIEL MOYEN----->          0       24       232       279       134
AUTRES EFFETS ORTHOGONAUX :           170      290       189      -113       134
                                      186      300        -5        55       134
                                       12      256       167       100       134
                                      205      129       209        -6       134
ECART.TYPE DES MESURES                296      386       389       392       388
ECART TYPE RESIDUEL            426
TEST EFFET MAXIMUM ?                           NON       NON       NON
TEST EFFET SIGNIFICATIF ?                      NON       NON       NON
(ECART-TYPE DES DIFFER DE MOY)          0      173       173       173
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 TRACTION DANS LE SENS TRANSVERSAL
DONNEES
 175 193 187    127 196 126    147 158 162    235 268 276
 126 118 131    125 153 143    151 152 135    161 153 128
 165 168 163    137 150 141    198 207 219    200 168 155
 207 215 205    211 201 178    141 128 126    200 198 207
                                     RIEN    FORMOL   LINDANE OX.ETHYLN     TOTAL
MOYENNE DES PIECES NON TRAITES       1874
EFFET DIFFERENTIEL MOYEN----->          1     -477      -148       -26      -162
AUTRES EFFETS ORTHOGONAUX :          -163     -300      -270        83      -162
                                      -36       19      -422      -211      -162
                                     -119     -311      -131       -89      -162
                                     -357     -217      -175        99      -162
ECART.TYPE DES MESURES                478      135       258       320       374
ECART TYPE RESIDUEL            184
TEST EFFET MAXIMUM ?                       MAXIMUM1       NON       NON
TEST EFFET SIGNIFICATIF ?                  BEAUCOUP       NON       NON
(ECART-TYPE DES DIFFER DE MOY)          0      147       156       166
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 TRACTION DANS LE SENS DE L'ECHINE
DONNEES
 258 238 239    270 273 273    230 213 257    175 200 195
 244 267 253    242 250 240    250 256 280    180 127 147
 242 219 237    192 207 219    315 300 266    205 208 224
 161 179 171    267 320 318    262 282 310    166 190 186
                                     RIEN    FORMOL   LINDANE OX.ETHYLN     TOTAL
MOYENNE DES PIECES NON TRAITES       2350
EFFET DIFFERENTIEL MOYEN----->          0      -70        11        -6       -16
AUTRES EFFETS ORTHOGONAUX :           -93      209       334      -514       -16
                                       58     -279       209       -52       -16
                                      202     -163        28      -131       -16
                                     -132       18      -200       250       -16
ECART.TYPE DES MESURES                317      467       371       616       458
ECART TYPE RESIDUEL            204
TEST EFFET MAXIMUM ?                           NON       NON       NON
TEST EFFET SIGNIFICATIF ?                      NON       NON       NON
(ECART-TYPE DES DIFFER DE MOY)          0      167       140       199
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PEAU DE CHEVRE 120 - VIEILLIE A LA CHALEUR

ECLATEMENT

DONNEES

238 235	250 233	275 253	218 200
201 146	268 269	256 256	243 230
182 189	279 203	336 338	258 201
262 270	191 257	254 215	235 271

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	2377				
EFFET DIFFERENTIEL MOYEN----->	0	-40	105	66	33
AUTRES EFFETS ORTHOGONAUX :	-223	60	351	-57	33
	360	53	-179	-102	33
	-12	-48	-133	325	33
	-5	-37	193	-18	33
ECART.TYPE DES MESURES	212	391	601	267	401
ECART TYPE RESIDUEL 219					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	158	226	122	

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DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

256 287 359	346 305 354	322 300 372	237 244 235
210 245 336	236 318 256	346 340 266	212 157 186
190 186 195	214 203 215	194 210 304	231 330 304
238 217 274	271 384 357	344 331 274	325 228 354

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	3013				
EFFET DIFFERENTIEL MOYEN----->	0	-423	-699	-15	-284
AUTRES EFFETS ORTHOGONAUX :	-518	-130	-10	-477	-284
	-240	-488	-4	-403	-284
	96	-243	-474	-515	-284
	-481	-150	-181	-323	-284
ECART.TYPE DES MESURES	479	610	488	538	607
ECART TYPE RESIDUEL 487					
TEST EFFET MAXIMUM ?		NON	MAXIMUM1	NON	
TEST EFFET SIGNIFICATIF ?		NON	BEAUCOUP	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	225	199	209	

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DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

316 338 290	302 308 316	285 324 321	257 350 247
246 220 251	254 265 310	254 248 228	190 158 173
224 185 205	233 201 185	328 322 250	244 232 263
362 344 315	268 354 279	335 296 296	287 222 274

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	3044				
EFFET DIFFERENTIEL MOYEN----->	0	-713	-650	-17	-345
AUTRES EFFETS ORTHOGONAUX :	-297	-314	-138	-629	-345
	-164	-357	-286	-572	-345
	-282	-503	-357	-237	-345
	-534	-499	-111	-234	-345
ECART.TYPE DES MESURES	292	406	449	392	515
ECART TYPE RESIDUEL 331					
TEST EFFET MAXIMUM ?		MAXIMUM1	MAXIMUM2	NON	
TEST EFFET SIGNIFICATIF ?		BEAUCOUP	BEAUCOUP	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	151	161	148	

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TRACTION DANS LE SENS TRANSVERSAL

DONNEES

196 184 178	196 215 191	150 157 156	147 144 140
165 169 153	146 157 170	121 135 147	107 147 136
191 201 190	178 194 193	136 109 140	185 158 137
176 201 181	128 172 170	172 170 168	146 119 143

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	1711				
EFFET DIFFERENTIEL MOYEN----->	0	-250	-34	-89	-93
AUTRES EFFETS ORTHOGONAUX :	109	47	-243	-286	-93
	-191	-80	21	-123	-93
	-118	-108	-47	-98	-93
	-25	-48	-66	-233	-93
ECART.TYPE DES MESURES	240	182	290	224	256
ECART TYPE RESIDUEL 168					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		UN.PEU	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	86	108	94	

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TRACTION DANS LE SENS DE L'ECHINE

DONNEES

212 215 194	203 230 210	203 226 223	141 127 114
154 150 155	213 170 200	74 160 166	103 116 118
148 162 160	216 230 226	226 229 226	128 122 113
199 148 149	189 208 185	194 186 180	162 143 143

	RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES	1914				
EFFET DIFFERENTIEL MOYEN----->	0	-431	-92	-175	-174
AUTRES EFFETS ORTHOGONAUX :	-209	152	-3	-439	-174
	30	-289	-226	-213	-174
	-275	-54	-251	-116	-174
	-89	-279	-169	-160	-174
ECART.TYPE DES MESURES	386	380	454	224	404
ECART TYPE RESIDUEL 227					
TEST EFFET MAXIMUM ?		NON	NON	NON	
TEST EFFET SIGNIFICATIF ?		UN.PEU	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)	0	156	172	129	

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PEAU DE MOUTON 64 - VIERGE

ECLATEMENT

DONNEES

156 130	204 204	206 203	184 193
152 166	141 106	179 194	156 180
160 129	170 205	186 159	174 148
131 156	200 204	196 195	182 155

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		1850				
EFFET DIFFERENTIEL MOYEN----->		0	-257	-186	-76	-130
AUTRES EFFETS ORTHOGONAUX :		-375	-57	47	-135	-130
		-331	-85	-51	-52	-130
		-118	-51	-220	-130	-130
		-115	-91	-268	-45	-130
ECART.TYPE DES MESURES		260	257	217	250	266
ECART TYPE RESIDUEL	136					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	129	119	127	

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DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

237 257 309	373 476 425	432 385 427	308 327 325
340 344 298	269 320 275	334 335 354	198 241 177
413 359 375	335 375 311	288 245 271	297 309 363
277 376 330	457 426 393	337 362 441	248 230 278

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		3567				
EFFET DIFFERENTIEL MOYEN----->		0	-654	-282	-104	-260
AUTRES EFFETS ORTHOGONAUX :		-304	137	-57	-816	-260
		-869	-244	70	2	-260
		-174	-231	-132	-502	-260
		-583	-67	-175	-215	-260
ECART.TYPE DES MESURES		715	573	476	729	679
ECART TYPE RESIDUEL	391					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			UN.PEU	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	264	247	294	

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DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

274 307 248	360 389 362	220 189 267	233 250 248
277 259 265	282 286 297	219 306 255	168 168 177
315 363 275	250 260 242	229 253 273	289 247 300
259 334 174	280 373 367	331 287 348	229 242 227

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		2788				
EFFET DIFFERENTIEL MOYEN----->		1	-322	-41	87	-68
AUTRES EFFETS ORTHOGONAUX :		3	335	-140	-473	-68
		-165	-263	307	-153	-68
		99	-348	141	-166	-68
		-238	163	-168	-32	-68
ECART.TYPE DES MESURES		598	485	359	607	544
ECART TYPE RESIDUEL	370					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	222	202	245	

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TRACTION DANS LE SENS TRANSVERSAL

DONNEES

115 121 106	136 123 125	56 56 71	98 114 115
104 89 93	102 103 95	107 95 105	36 39 47
134 119 118	89 86 90	107 100 89	112 114 109
116 123 117	119 111 113	96 110 109	70 75 80

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		1030				
EFFET DIFFERENTIEL MOYEN----->		0	-184	25	2	-38
AUTRES EFFETS ORTHOGONAUX :		99	46	-112	-189	-38
		-60	15	70	-180	-38
		75	-230	64	-65	-38
		-160	42	-51	13	-38
ECART.TYPE DES MESURES		261	259	143	176	232
ECART TYPE RESIDUEL	79					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	106	85	90	

****

TRACTION DANS LE SENS DE L'ECHINE

DONNEES

125 155 159	170 185 176	182 179 196	126 117 146
100 131 130	182 170 137	172 164 170	77 78 88
150 139 152	201 210 192	172 151 173	140 151 180
153 145 158	172 170 163	168 183 204	68 90 137

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		1596				
EFFET DIFFERENTIEL MOYEN----->		0	-263	71	-86	-69
AUTRES EFFETS ORTHOGONAUX :		-181	169	165	-431	-69
		-163	24	2	-141	-69
		4	-91	-34	-157	-69
		-71	-118	48	-136	-69
ECART.TYPE DES MESURES		251	375	223	364	335
ECART TYPE RESIDUEL	177					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			UN.PEU	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	130	96	127	

****

PEAU DE MOUTON 628IS - VIEILLIE A LA CHALEUR

ECLATEMENT

DONNEES

156 165	201 264	227 232	208 231				
126 154	184 180	203 196	203 208				
176 177	205 238	226 210	220 222				
157 154	174 205	217 233	222 215				

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		2105				
EFFET DIFFERENTIEL MOYEN----->		0	-287	-12	-133	-108
AUTRES EFFETS ORTHOGONAUX :		-523	-41	75	56	-108
		-157	-115	-58	-102	-108
		-178	-81	-97	-76	-108
		-73	-37	-135	-187	-108
ECART.TYPE DES MESURES		338	266	210	289	302
ECART TYPE RESIDUEL	137					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	152	140	157	

****

DECHIRURE DANS LE SENS TRANSVERSAL

DONNEES

320 264 270	540 460 445	329 325 301	290 384 460
320 338 330	342 318 330	346 362 364	227 258 255
374 353 303	300 333 306	336 326 374	445 445 475
360 292 199	433 374 374	460 460 470	278 322 354

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		3656				
EFFET DIFFERENTIEL MOYEN----->		0	-497	-14	-9	-130
AUTRES EFFETS ORTHOGONAUX :		-553	139	54	-161	-130
		-461	-326	667	-401	-130
		70	-459	130	-262	-130
		-386	94	-188	-40	-130
ECART.TYPE DES MESURES		862	427	578	797	720
ECART TYPE RESIDUEL	448					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	280	299	338	

****

DECHIRURE DANS LE SENS DE L'ECHINE

DONNEES

179 144 155	273 303 358	262 198 284	372 354 376
181 238 175	204 276 260	445 428 284	278 220 250
365 308 277	420 301 224	224 188 154	328 324 304
198 137 175	380 348 364	280 344 314	183 198 198

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		2714				
EFFET DIFFERENTIEL MOYEN----->		1	-14	133	-114	1
AUTRES EFFETS ORTHOGONAUX :		-604	378	123	106	1
		-744	381	137	231	1
		355	-329	394	-415	1
		-123	302	-255	81	1
ECART.TYPE DES MESURES		818	822	725	832	805
ECART TYPE RESIDUEL	507					
TEST EFFET MAXIMUM ?			NON	NON	NON	
TEST EFFET SIGNIFICATIF ?			NON	NON	NON	
(ECART-TYPE DES DIFFER DE MOY)		0	334	315	336	

****

TRACTION DANS LE SENS TRANSVERSAL

DONNEES

150 160 101	235 107 144	135 120 107	120 107 120
88 96 82	79 70 88	101 103 96	115 120 110
98 98 97	126 134 135	90 94 87	144 145 129
95 90 91	140 135 130	110 127 112	72 87 88

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		1338				
EFFET DIFFERENTIEL MOYEN----->		0	-381	-190	-273	-211
AUTRES EFFETS ORTHOGONAUX :		-299	-68	-269	-207	-211
		-366	-239	-72	-167	-211
		-59	-279	-316	-189	-211
		-88	-233	-260	-263	-211
ECART.TYPE DES MESURES		354	144	215	214	281
ECART TYPE RESIDUEL	241					
TEST EFFET MAXIMUM ?			MAXIMUM1	NON	NON	
TEST EFFET SIGNIFICATIF ?			BEAUCOUP	NON	UN.PEU	
(ECART-TYPE DES DIFFER DE MOY)		0	123	123	123	

****

TRACTION DANS LE SENS DE L'ECHINE

DONNEES

245 250 174	178 182 166	230 250 245	162 164 182
135 140 102	190 174 170	160 170 170	137 126 153
160 158 144	200 220 210	250 220 265	169 161 189
165 215 200	174 174 142	199 188 200	153 122 176

		RIEN	FORMOL	LINDANE	OX.ETHYLN	TOTAL
MOYENNE DES PIECES NON TRAITES		2023				
EFFET DIFFERENTIEL MOYEN----->		0	-500	-68	-266	-208
AUTRES EFFETS ORTHOGONAUX :		-283	-206	99	-444	-208
		-32	-174	-348	-278	-208
		-208	-203	-280	-142	-208
		-104	-407	-58	-264	-208
ECART.TYPE DES MESURES		360	238	370	259	368
ECART TYPE RESIDUEL	198					
TEST EFFET MAXIMUM ?			MAXIMUM1	NON	NON	
TEST EFFET SIGNIFICATIF ?			BEAUCOUP	NON	UN.PEU	
(ECART-TYPE DES DIFFER DE MOY)		0	124	149	128	

THIN LAYER CHROMATOGRAPHY

AN AID FOR THE ANALYSIS OF BINDING MATERIALS AND NATURAL DYESTUFFS FROM WORKS OF ART

Wilma G.Th. Roelofs

I C O M

INTERNATIONAL COUNCIL OF MUSEUMS / CONSEIL INTERNATIONAL DES MUSÉES
COMMITTEE FOR CONSERVATION COMITÉ POUR LA CONSERVATION

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Contents

1. Introduction

To analyse organic materials various methods can be used, the most widely used are infraredspectrometry, NMR and various types of chromatography.

Specific problems arise in analysing organic materials from objects of art, for instance dyestuffs from textile materials, binding media from paintlayers of polychromed sculptures or paintings, dyestuffs and binding materials from illuminated manuscripts.

As the object is not to be damaged the samples have to be minute.

A second problem is that the materials used by the ancient artists were in most cases complicated mixtures. Also the pure dyestuffs, binding media and other auxiliaries were polluted with traces of other materials.

To obtain more information about the materials used and about the workshop technics it is necessary to examine systematicly a great number of samples from a group of paintings or textiles.

On the other hand specific problems are sometimes required, for instance by a restorer who is working on an object.

To obtain good results at relative short term, thin-layer chromatography proves to be an excellent method.

Infraredspectra and NMR often are disturbed by impurities in the sample and mixtures also might give some difficulties.

The methods are good but it is very time consuming to prepare the samples for analysis. Also the quantity of the needed material is relatively large (3, 12).

For thin-layer chromatography sample preparation is very simple and costs little time and the quantity of the needed material is very small. The only drawback of this method might be that it requires great experience to identify the spots and that there is a lack of ancient reference materials.

2. General concepts

For the analysis of complex mixtures chromatographical separation techniques have become more and more important since the beginning of this century. These methods, based upon adsorption and partition, have their origin in the dyestuff-industry; from 1830 till 1900 papers were published already by e.g. Runge, Goppersruder, Schönbein and Reed.

The first chromatographical - analytical method was practised by the Russian botanist Tswett (1903), who succeeded in separating a mixture of vegetable dyes on a column of calciumcarbonate.
Various chromatographical techniques have their origin in Tswett's column chromatography: one tried e.g. to impregnate filter paper with alumina and to use this as a solid phase for chromatography. This led to the famous paperchromatography by Martin, Cousden, Gordon and Synge (1914). Others kept trying adsorbents in the powder form; Ismailov (1938) used pulverized alumina, that was sprinkled in a thin uniform layer upon a glass plate. From this the circular chromatography originates. Ismailov also made first efforts to attach the adsorbent to the glass plate and to use it for chromatography. (2,6) This method was further developed by Egon Stahl (1958) to the present thin layer chromatography .(11)
One of the main reasons which have led to the stormy development of this technique and in an increasing degree of column chromatography is, that the problem of the very pure adsorbents is solved for the greater part by better manufacturing methods.
First the general principles of chromatographical separation will be dealt with and later the practical aspects of the technique.

2.1. Forms of Chromatography

In the analysis by Tswett an extract of vegetable dyes in ligroin is running through a glass tube, filled with an adsorbent, calcium carbonate.

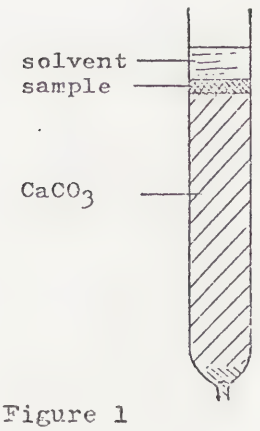


Figure 1

Figure 2

It is observed that in the upper part of this chromatographical column the dyestuffs are adsorbed in narrow bands or zones, while the pure solvent follows its way through the adsorbent. The solvent can be catched under the column. The adsorbed molecules may be removed from the column by washing (elution) with a liquid or a mixture of liquids of a higher degree of polarity (mobile phase). For the reason of selective adsorption the different dyestuffs migrate through the column at different rates, and in case of continuing elution they can be catched from the column seprarately (fig. 2).

Nowadays many variants of Tswett's method are applied, whereas chromatographical methods are not only practised in the analysis of coloured compounds, but also in the investigation of colourless materials.

The basic principle is equal to each technique: a mobile phase moves along a stationary phase; the mixture to be separated is distributed over both phases and the components of the mixture migrate at different rates along with the mobile phase.

The mobile phase may be a gas or a liquid (gaschromatography or liquid-chromatography).

Gaschromatography is very appropriate for the separation of small amounts of volatile compounds: separation on a preparative scale can be achieved better by liquid-chromatography up to now.

Liquid-chromatography can be subdivised in:

1. Liquid-solid-chromatography (adsorption-chromatography)
2. Liquid-liquid-chromatography (partition-chromatography).
3. Electro-chromatography
4. Chromatography on ion-exchange-columns.
5. Gelfiltration

For our purpose only the liquid-solid-chromatography and the liquid-liquid-chromatography are of importance.

The fundamental difference between both forms is the stationary phase. When it exists of a material which is able to adsorb the components of a mixture selectively to its surface one has adsorption-chromatography; when the stationary phase is a liquid, attached to a certain carrier material, one has partition-chromatography.

Generally in adsorption-chromatography the mobile phase is a liquid of relative small polarity and the components of the sample are also little polar. In the case of partition-chromatography on the contrary the mobile phase and the sample compounds are often strongly polar. There is however no sharp distinction between adsorption- and partition-chromatography and in practical work this aspect does not interfere.

Apart from column-chromatography thin layer chromatography is a form of adsorption-chromatography and paper-chromatography is an example of partition-chromatography.

In paper-chromatography water, which is always present in cellulose, acts as the stationary phase and cellulose itself as carrier material. (2)

In thin layer chromatography the separation is carried out on a thin layer of adsorbing material, which is attached uniformly to a glass, plastic or aluminum plate. The mixture to be separated is spotted some cm. from the bottom of the plate and the plate is placed in a closed trough, in which a layer of half a cm. of the mobile phase covers the bottom.

The liquid migrates upward in the thin layer and the components of the sample run along with the liquid in the same direction at different rates. The separated compounds are visible in the chromatogram, after detection, in the form of more or less round stains (1). (fig. 3)

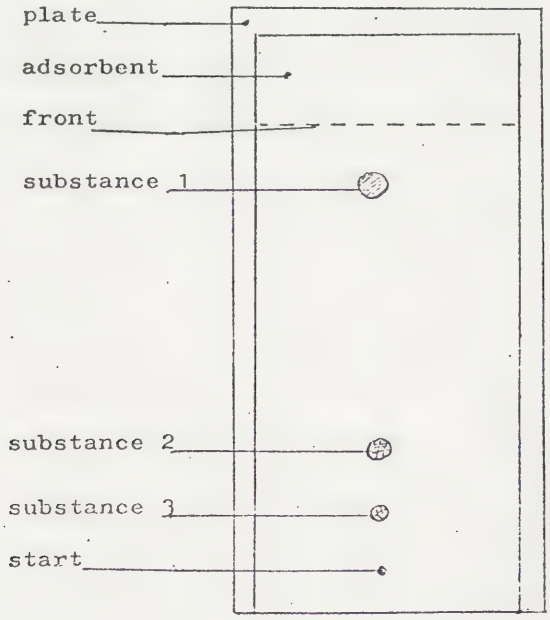


Figure 3.

3. The approach of a chromatographical problem.

3.1. General

The application of chromatographical methods will have as the main purpose to answer the questions, which have been asked regarding the sample, quickly and concretely.
It is important that the practical circumstances under which the separations are carried out be optimized: theoretical considerations take the second place when it comes to results.
Of most mixtures under investigation one often does not know more than the purpose for which they have been used or the way they were made, so that one can have a guess about the nature of the components of the mixtures only. In such cases one will have to find the solution for the problem by "trial and error".
With aid of some simple considerations and a lot of experience one may often tackle the problem effectively. (10)

3.2. The choice of adsorbent and eluent.

In each chromatographical system the mixture, the stationary phase and the mobile phase are the three magnitudes which are balanced with eachother: the common factor of the greatest importance is the polarity. Depending on their polarity compounds stronger or weaker may be adsorbed to the adsorbent and adsorbents may be distinguished according to their activity.
Weak adsorbents are diatomaceous earth and magnesium silicate, strongly active are silica gel and alumina.
The migration velocity of a compound on a certain adsobent depends on the mobile phase which is used.
Here follows the eluotropic series, arranged according to increasing polarity:
ligroin , cyclohexane , carbontetrachloride , trichloroethane , toluene , benzene , dichloroethane , chloroform , butylacetate , diethylether , ethylacetate , butylalcohol , propanol , acetone , isopropylalcohol , ethylalcohol , acetic acid , methanol , water.
Further refinings can be made by the use of mixtures of liquids.
E.g.: benzene/ethylacetate = 80/20 vol. parts or
chloroform/methanol = 95/5 vol. parts.

The choice of adsorbent and mobile phase may be roughly derived from fig. 4

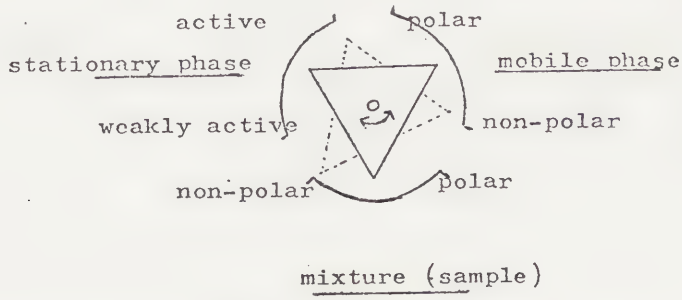


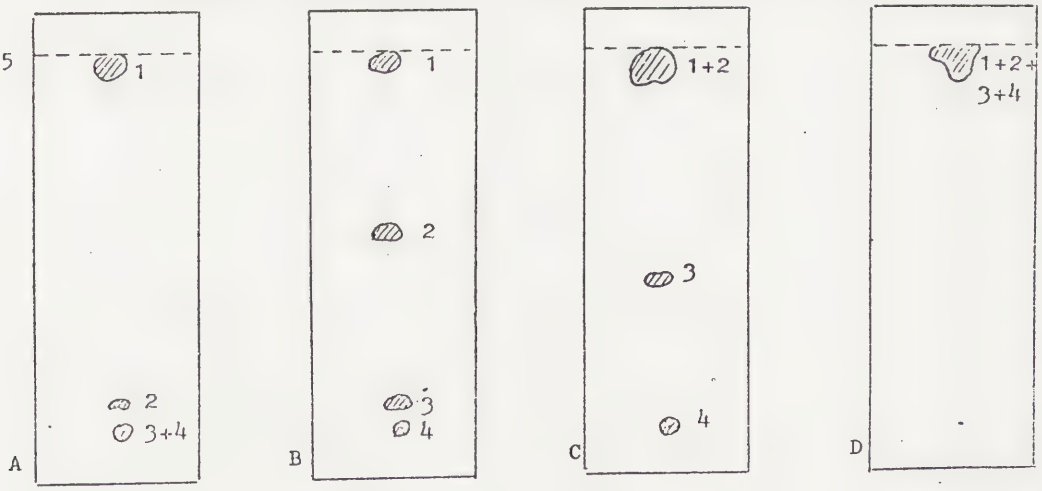
Figure 4.

One of the angles of the equilateral triangle is brought in the appropriate position on the scale of the polarity of the sample; from the other angles one can read in which range to choose the adsorbent and the elution system (11).

3.3. The separation

The proper circumstances for a good separation can be found very quickly by means of thin layer chromatography on microscope slides, for which the developing time is about five minutes. The first trials to the eluent may be ligroin, chloroform and methanol in order to get a first idea on the polarity of the compounds present. Depending on the results mixtures of the first two, respectively the last two liquids are tried, if necessary other members of the eluotropic series are chosen. An example is given in fig. 5

fig. 5



A. Ligroin , B. Ligroin/chloroform = 4/1 vol. part

C. Chloroform , D. Chloroform/methanol = 2/1 vol. part

4. Thin layer chromatography (1,10,11).

4.1. General

In comparison with the principially and practically comparable paperchromatography thin layer chromatography does offer advantages, which favour the application:

1. short developing times: 15 - 45 min., depending on the polarity of the mobile phase (5 - 10 min. on microscope slide. Paper-chromatography takes 10 to 24 hours or even days.
2. high separating power on short distances.
3. the possibility of using agressive reagents (paper is damaged by sulphuric acid).
4. simple and non-volumninous apparatus.
5. a wide range of adsorbents.

4.2. The preparation of the chromatoplates

4.2.1. The adsorbent

The most important adsorbents are: silica gel, alumina, diatomaceous earth and cellulose powder. T.L.C.-adsorbents are available as:

- pure adsorbent
- adsorbent plus binder (e.g. gypsum, starch, polyvinylalcohol)
- adsorbent plus inorganic fluorescence-indicator.
- adsorbent plus binder plus fluorescence-indicator.

REMARK: The mechanical strength of the layer is increased by the presence of gypsum, but one has to take into account that calsiumsulphate is a weak active material and that the separation may be influenced unfavourably.

4.2.2. The application of the thin layer

The commercially available apparature of e.g. Stahl and Camag, by means of which the adsorbent suspension is applied to the glass plates is rather expensive and to the author's opinion not even optimum appropriate.

A very inexpensive way of preparation of the plates is as follows:

Remove traces of grease thoroughly with alcohol.
An aqueous suspension of the adsorbent is applied uniformly to a row of chromatoplates. The only requisites are selfadhering tape, a smooth table and a rustless steel bar of 25 cm. length and 1 cm. diameter. A number of plates is placed in a row next to each other and the plates are sticked to the table by means of a 1 cm. broad tape, which covers the plates for a width of 3 to 5 mm. The protruding part of the tape is sticked to the table, so that the construction can not be moved. The plates have to be dried in the oven at 110° C.
Nowadays many types of plates are commercially available, ready for use. The advantages are the decreased hazard of inhaling finely divided adsorbent material, the time saved and the possibility of cutting an appropriate size from a plastic or aluminum plate.

4.3. Further preparation and application of the sample

4.3.1. Marking of start and finish

Before application of the sample to the plate a broad strip of adsorbent is scratched from three sides of the plate with aid of a teflon scratcher enabling easy handlings of the plate and preventing edge effects.
The samples to be separated have to be applied 2 cm. from the bottom and the mutual distance should not be less than 1 cm.
The markings can be done with aid of a stencil plate.

4.3.2. Solvent and amount of sample

Preferably the sample is dissolved in a volatile solvent of low polarity. The solvent has to evaporate quickly and in case of a non-polar solvent one can achieve small start spots, and so no chance of getting a circular chromatogram.
The concentration of the components in the sample solution (about one drop) may vary between 0,01 and 0,5%. The various compounds in the sample may be present in amounts of 1 to 10 micrograms. E.g. in a sample mixture with three components present in comparable quantities the total quantity of material to be applied may be 30 micrograms

4.4. The separation chamber

A separation chamber should have a well locking cover and a flat bottom. The volume of the chamber should be chosen according to the size of the plate. Apart from the frequently used rectangular troughs with ground upper edge and cover one can also use preparation cylinders and sample flasks with screw cap, it they can be closed satisfactory.

If the cap does not fit properly there will be no equilibrium between the vapour phase and the liquid phase during the separation and the bad chance is the occurrence of edge effects in the chromatogram.

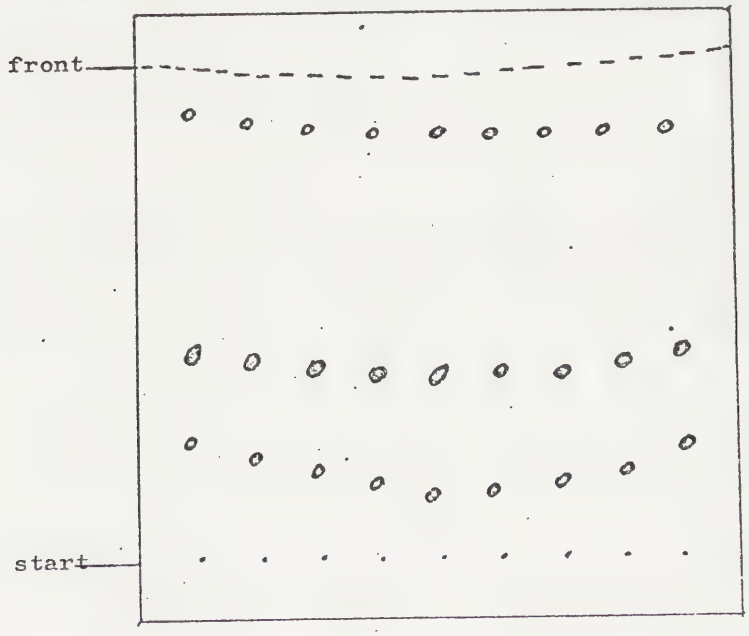


Fig. 7 Edge effects.

This phenomenon is very nasty when it comes to identification of substances by means of comparison.

One may speed up the reaching of the state of equilibrium by covering the walls of the trough with filterpaper impregnated with the eluent.

The situation to the saturation is still not always ideal, but the edge effects are supressed for the greater part. One may expect that saturation is best effected in chambers of small volumes.
The famous sandwich chamber is formed by a glass plate with the thin layer and the samples and a second plate of equal size without adsorbent. Between these two plates along three edges strips of teflon or cardboard are placed.
Like that one has obtained a chamber of relatively very small volume. The development is started by placing this chamber, with the open side downward, in a glass trough, through a metal cover. The opening through which the plates fit in the cover has exactly the same size as the cross section of the two plates, so that no vapour of the eluent will escape. Sample jars with a screw cap make good separation chambers for Thin Layer Chromatography on microscope slides.

4.5. The eluents

Depending on the nature of the compounds to be separated the composition of the eluent is determined with aid of the eluotropic series.
An absolute condition is, that the eluent components be pure and leave no residue after evaporation. The so called pro analysi and pro chromatography grades should be redistilled with care before use. A mixture of liquids that has stayed in the chamber for a long time has to be replaced, because the composition will have changed due to fractional evaporation.

4.6. The dosage or application of the sample

Very simple apparatus can be used for the dosage of the samples. A very thin capillary can be pulled out of a Pasteur pipet after moderate heating in a small flame. The narrower the capillary, the smaller the start spot will be. The surface of the spot can also be limited by making the solvent evaporate each time after the application of a small volume of sample solution.

4.7. The development

When the samples have been applied to the start and the solvent is evaporated, the plate is placed vertically in the separation chamber, in which the eluent stands at a height of about half a cm. The trough is closed immediately, When the liquid front has risen to a height of 10 cm. the plate is taken out of the chamber, the eluent front is marked and the plate is dried with a hot air blower.

Drying is continued until all adhering liquid is gone.

The most important condition to be fulfilled in the development is the constantness of the temperature. Already small temperature gradients within the chamber will lead to undesirable effects, e.g. a skew eluent front.

4.8. The detection

4.8.1. Procedure and apparatus

After the development the compounds are present in the chromatogram, separated, in the form of round stains.

In the case of coloured compounds detection does not give any problems. Otherwise the spots have to be stained or made visible by other means. Detection reagents are sprayed on the plate with the aid of an atomizer (be careful, not too wet).

Often the chromatogram has to be heated after spraying to promote the colouring.

REMARK: Spraying should always be done in the fume hood, because of the toxicity or the acidity of the sprays.

Spraying apparatus is also commercially available together with the detection reagent. Many frequently used detection solutions are available for refilling.

4.8.2. Non-destructive detection

Many compounds become visible by the absorption or fluorescence of ultra violet radiation, either the short wave radiation of 250 nm or the long wave light of 366 nm.

REMARK: The radiation from ultra violet lamps is very harmful to the eyes. One should at least wear glass safety spectacles or preferably ultra violet safety glasses.

Another non-destructive detectionmethod is iodine, which gives a brown colour to the greater part of the organic compounds.. Iodine is bound physically to the components and on lying in the open air the iodine evaporates again, so that the spots remain undisturbed.

4.8.3 Spray reagents for the identification of samples from works of art.

The compounds are converted chemically. Amino acids from glues are coloured pink by ninhydrin. The components of resins from black spots with a spray of antimonypentachloride in carbon-tetrachloride and heating afterwards.

Sugars, from gums, are sprayed with a solution of naphthoresorcinol in alcohol. The components of red dyes are coloured blue, violet, purple, orange and pink with an alcoholic solution of potassium hydroxide (10).

For yellow natural dyes the flavon reagent is used, 2-amino-ethyldiphenylborate (7).

General spray reagents are e.g. potassium dichromate, potassium permanganate, phosphomolybdic acid, sulphuric acid.

4.9. The chromatogram

In a good chromatogram the spots have a symmetrical form and the highest concentration of the compound should be present in the centre of the spot. Spots with R_F-values differing by 0,03 to 0,05 can be observed seperately.

R_F is the figure denoting the range of flow of the compound, also explained as the retardation factor.

The compounds migrate at different rates in a chromatographic separation and after a certain time they are found at different spots on the plate. The front of the eluent which has not been hindered by adsorption or partition has covered a greater distance in the same time.

R_F will always have a value between 0 and 1.
As R_F is very much depending on:

1. the saturation
2. the temperature
3. the thickness of the thin layer
4. the concentration
5. the composition of the eluent,

R_F is not an easy magnitude to work with. Problems in identification can be solved excellently by using standard materials running on the same plate.
So together with the unknown sample those standards are applied to the plate, which are likely to be present in the sample.

5. <u>The approach of a chromatographic problem in analysing binding materials from paintlayers</u>.

Samples have been taken from the painting or polychromed sculptures by means of very small scalpels. From these samples cross--sections are made. With the micro-manupulator the samples are separated into layers.
Under the microscope one can get the impression what kind of binding material is present.
When it is not possible to give a suggestion about the binding material the following scheme is followed

A. <u>Dissolve the sample in chloroform</u>

G.L.C. Test	T.L.C. Test
	Resin
Oil	
	Wax

When the result is negative ----→ B

B. Hydrolyze the sample and dissolve in warm water

	T.L.C. Test gums (sugars)
	glues (amino acids)

* Note: When the result is negative it is also possible the sample was too small.

5.1. Thin-layer Chromatographic system for resins.

Adsorbent:	Silicagel with gypsum
Eluent:	Chloroform
Distance covered:	3 x 10 cm. *
Detection:	Spraying with a 20% solution of ANTIMONY-pentachloride in carbontetrachloride.
Typical Standard:	Copal, Sandarac, Venice turpentine, Elemi, Shellac, Damar, Colopony, Mastix, Amber.

* Note: For better separation of the spots it is necessary to chromatograph three times.

5.1.1. Preparation of a sample from a varnish

In most cases the main component of varnish is a resin. A sample from the toplayer can be taken very easy by means of a cotton swab drenched in chloroform. (To clean the cotton wool, it is first extracted with pure chloroform).
Rub very carefully with the wetted cotton wool over the varnish layer. In this case, enough resin is dissolved for a chromatographic test.
The cotton wool is extracted with chloroform and this is evaporated to a small quantity. Then the solution is spotted and chromatographe

5.2. Thin layer chromatographic system for waxes.

Adsorbent:	Silicagel + alumina 1:1
Eluent:	Heptane/ether/acetic acid/90:10:2/
Distance covered:	1 x 10 cm.
Detection:	Spraying with a solution of potassium-dichromate in sulphuric acid: heating at 110° C for about 10 minutes.
Typical standard:	Beeswax

5.3. Method of Hydrolysation.

The sample is put in a small glass tube. About five drops of 0,3 N hydrochloric acid are added. The glass tube is closed from the air by melting the top of the glass tube. Then it is placed in an oven with a temperature of 105° C. for about twelve hours.

After hydrolysation evaporate to dryeness and add one or two drops of water and heat. This solution is spotted and chromatographed.

5.4. Thin layer chromatographic system for gums. (13)

By hydrolysation gums are discomposed into sugars.

Adsorbent:	Silicagel
Eluent:	Propanol/ethylacetate/water/ammonia/ 20:5:15:5/
Distance covered:	1 x 10 cm.
Detection:	Spraying with a solution of 44 mg. naphtoresorcinol/22 ml. ethanol/1ml. H_3PO_4 heating at 120°C. till spots are visible.
Typical standard:	Arabinose, glucose, fructose, xylose, rhamnose, galactox.

5.5 Thin layer chromatographic system for glues.

By hydrolysation glues are decomposed into amino-acid.

Adsorbent:	Silicagel
Eluent:	Phenol/water/75weight:% 25 weight %.
Distance covered:	1 x 10 cm.
Detection:	Spraying with a solution of: A. 50 ml. 0.2% ninhydrin in ethanol/10 ml. Acetic acid (glacial)/ 2 ml. 2,4,6 - trimethylpyridine (γ-collidine). B. Cu $(NO_3)_2 \cdot 3\ H_2O$, 1% in ethanol. Mix just before use 50 vol. % A. and 3 vol % B. Heating at 120°C till spots are visible.
Typical standards:	Bone glue, albumen, eggwhite, rabbitglue.

6. Chromatographic analysis of natural dyestuffs.

6.1 Sample preparation.

Natural dyestuffs occur in various kinds of objects of art, f.i. paintings, illuminated manuscripts, textiles.
However, sample preparation is in all cases about the same. Except some vat-dyestuffs as indigo and purple, most dyestuffs are mordant dyestuffs and are present in the objects as a lake, a metal complex mostly with aluminium, iron and tin.
This complex has to be decomposed by hydrolysation. The sample is put in a small glass tube, one drop of hydrochloric acid is added and is heated for a few minutes. Then two drops of methylalcohol are added, the solution is again heated, spotted and chromatographed.

6.2 Thin layer chromatographic system for yellow dyes.

Adsorbent:	Silicagel (precoated sheets Polygram).
Eluent:	Toluene/ethylformiate/formic acid/ 5:4:
Distance covered:	1 x 10 cm.
Detection:	Spraying with 1% alcoholic solution of amino ethyldiphenylborate, the observat under UV-light, wave length 360 nm.

Typical standards:	Weld, fustic, fisetin (young fustic), safflower, saffron, turmeric, rhamnetin (Persian Berries) quercetin.

6.3. Thin layer chromatographic system for red dyes.

Adsorbent:	Acetyled cellulose 300 Ac-10 or 300 Ac-30 (precoated sheet).
Eluent:	Ethylacetate/tetrahydrofuran/water/6:35:45/
Distance covered:	1 x 10 cm., the sheets are prewashed with the eluent concerned.
Detection:	Spraying with 1-2 % alcoholic solution of potassium hydroxide, then observation under UV-light, wave length 360 nm.
Typical standards:	Madder (alizarin and purperin) cochineal (carminic acid) Kermes, various red-woods, henna, alkanet, lac-dye, archil.

Note: Green, orange and brown shades are chromatographed with both systems.

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THIN LAYER CHROMATOGRAPHY

AN AID FOR THE ANALYSIS OF DYEING MATERIALS AND NATURAL DYESTUFFS FROM WORKS OF ART

Wilma G.Th. Roelofs

Summary

To analyse organic materials various methods can be used, the most widely used are infraredspectrometry, NMR and various types of chromatography.

Specific problems arise in analysing organic materials from objects of art, for instance dyestuffs from textile materials, binding media from paintlayers of polychromed sculptures or paintings, dyestuffs and binding materials from illuminated manuscripts.

As the object is not to be damaged the samples have to be minute.

A second problem is that the materials used by the ancient artists were in most cases complicated mixtures. Also the pure dyestuffs, binding media and other auxiliaries were polluted with traces of other materials.

To obtain more information about the materials used and about the workshop technics it is necessary to examine systematicly a great number of samples from a group of paintings or textiles.

On the other hand specific problems are sometimes required, for instance by a restorer who is working on an object.

To obtain good results at relative short term, thin-layer chromatography proves to be an excellent method.

Infraredspectra and NMR often are disturbed by impurities in the sample and mixtures also might give some difficulties.

The methods are good but it is very time consuming to prepare the samples for analysis. Also the quantity of the needed material is relatively large (3, 12).

For thin-layer chromatography sample preparation is very simple and costs little time and the quantity of the needed material is very small. The only drawback of this method might be that it requires great experience to identify the spots and that there is a lack of ancient reference materials.

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Recent Developments in Infrared Reflectography of Paintings and its Applications in Art History

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International Council of Museums
Committee for Conservation

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Working Group: Non-destructive Methods of Examining
Works of Art and their Application

Recent Developments in Infrared Reflectography of Paintings and its Applications in Art History

J.R.J.van Asperen de Boer

Abstract

Although the technical background of infrared reflectography has been described earlier, recent experience in using the method has shown the importance of certain technical aspects of the instruments used and the proper storage and retrieval of information.
Some of these aspects are detailed in this report.
The necessity for multidisciplinary collaboration to achieve results is stressed. A survey is given of various approaches to apply the method in art history.
Preliminary results are briefly mentioned and suggestions are given for further work. The systematic comparison of underdrawings as revealed by infrared reflectography in paintings from a particular 'Group' would seem to be the most promising way. Grouping around authenticated paintings is shown to be possible and attempts to obtain a chronology based on underdrawings are reported.
The possibilities to improve the infrared-to-visible image translation systems suitable for infrared reflectography are briefly discussed.

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1. Introduction

Infrared photography has been used occasionally in the scientific examination of paintings. Most early applications concern restoration problems; sometimes a modification visible in the infrared photograph and diverging from the painted surface was recognized. The first systematic application with a specific art historical purpose would seem to be the discussion by Desneux (7) of underdrawings visible in infrared photographs of various paintings by Jan van Eyck. Lavalleye (19) and Van Schoute (32) have used infrared photographs in their work on Justus van Ghent and Rogier van der Weyden respectively. Van Schoute also discussed infrared photographs from Bosch paintings (33). The most stimulating contribution, however, has been made by Taubert who in his thesis (24) described various characteristic aspects of the underdrawing in relation to the creation of a painting. His analysis of underdrawings as visible in infrared photographs of paintings by Van Eyck, Dirk Bouts and Memling still retains its acuteness and his conclusions have been confirmed by later investigations with the technique described in this report (Cf. section 4.4.1.3).
The study of underdrawings would indeed seem the greatest challenge presented by the potentialities of infrared photography and reflectography.
The art history of Early Netherlandish painting in particular is dependent on attributions, although only very few existing paintings can be allocated with a safe historical margin to a particular artist (10). Attributions have almost exclusively been based on observations related to the visible surface of the painting. Therefore, theoretically, a totally new system of attributions could be based on underdrawings. The remaining problem would be to investigate the various steps leading from an underdrawing to a finished picture and the relative contributions of possibly various hands to the final appearance of the painting.
With such a prospect in mind the limitations of infrared photography are obvious. The best results in detecting underdrawings have been obtained in reddish, whitish and occasionally brownish areas. Greenish and bluish areas are, however, rarely penetrated by infrared photography. Infrared photography thus makes the underdrawing, when present, only partially visible. Some improvement can be obtained by using infrared image converters. Although such instruments, developed for military use, have occasionally been reported as used for the examination of paintings Heiber seems to have been the first to publish actual results (16). His photographs of the image on the S-1 cathode tube of the infrared image-converter indicate an improved

detection of underdrawings; but the instrument is not successful in detecting underdrawings under most green paint layers (28, p. 45). This detection technique is thus not always satisfactory.

The development of infrared reflectography as a method for the examination of Earlier European paintings represents an effort to improve the detectability of underdrawings and to investigate the possibilities and limitations of such an approach.
As in photography the painting is illuminated by a lightsource and the reflected radiation is received by the detecting instrument. The infrared reflectograph translates the infrared image into a visible image. The image is obtained by a scanning process. Thus unlike ordinary photographs the reflectograms consist of horizontal lines. The infrared radiation used in reflectography is able to penetrate paint layers better than the light used in infrared photography. The paint layers thus become more 'transparent' and the underdrawing can be made visible in a more complete way than is possible with infrared photography.
The technical background of this research has been published previously and the reader is referred to the litterature for an extensive description (26, 27, 28). In this report emphasis is being put on applications of the method in art history and a number of practical aspects is discussed in detail. It is hoped that those considering the use of the system may thus profit from recent experience.
Ideally infrared reflectography should be carried out with an infrared-to-visible image translating system with a maximum sensitivity at about 2.0 microns (20.000 Å) of the light used to illuminate the painting.[1] The first instrument used for infrared reflectography, a Barnes Infrared Camera did fulfill this condition very well, but had some disadvantages. In a later stage of the research an infrared vidicon television system was used. This detection system is quicker and more elegant but not quite maximalised with regard to wavelength response. A great advantage of this system, however, is the possibility of information storage and retrieval using a video-recorder.

2. Various technical aspects of the instruments used in infrared reflectography

2.1 Operation of the infrared vidicon tube

The operation of the Barnes Infrared Camera used in the earlier stages of the development of infrared reflectography has been described elsewhere (28, pp.

49, 50). Although the modified instrument is very satisfactory from the point of view of system sensitivity[2] it is slow and does not allow easily the reflectography of both details and larger areas, although this could be improved by using different mirror optics.
In using an infrared vidicon tube in a television system a much quicker and more elegant operation can be obtained. The infrared vidicon has various less satisfactory aspects in comparison with the Barnes Camera as a detecting system and these have also been described elsewhere (28, chapter 6). The most important drawback in actual operation is retained here: i.e. the heating-up of the Infrared Resistron 2000 IND vidicon-tube. This occurs in about an hour and causes an image of poor contrast due to thermal noise. The vidicon 'sees' part of the radiation emitted by the heated tube and its surroundings. Although various devices have been published to cool infrared detectors, some of them applicable to infrared vidicons, it has not been attempted so far to adapt such improvements to the reflectography system. In practice operation is stopped after an hour and the tube is allowed to cool off for about thirty minutes. An alarmclock is useful to remind the operators. A record is kept of the time during which the tube has been operated. Infrared vidicons may be used for c. 500 operating hours but this figure depends on the operating conditions.

2.2 Lenses

Infrared imaging systems capable to detect radiation with wavelengths longer than about 2.0 microns usually employ mirror optics or lens-systems made of special optical materials transmitting such longer infrared radiation. For the imaging of radiation up to 2.0 microns the same optical systems can be used as are common in ordinary photography. The glass used in such lens-systems transmits radiation up to c. 4 microns. Therefore no special lenses need to be used with the infrared vidicon. The choice of a lens would seem mostly to be governed by financial considerations. A SOM-Berthiot-Cinor 1:3.8, f = 17-85 mm zoom lens has been used successfully by the author. Some caution may be required with lenses especially coated for optimal functioning in the visible region of the spectrum. In any case it is recommended to obtain a transmittance spectrum of the lens (i.e. a graph of transmittance versus wavelength of incident light) before purchasing a particular item. A combination of a zoom lens with auxiliary lenses may be sufficient for most practical situations. Areas to be reflectographed will rarely exceed c. 30 x 40 cm and such a

surface will set one limit. It may be useful to select the lens-system in such a way that it may image areas of 1 cm^2. This is, e.g., required in the examination of illuminated manuscripts and small panel paintings. The focusing may, however, become rather delicate under such circumstances.

2.3 Filters

To obtain good results it is necessary to use filters in front of the camera lens-system. The same filters may be used as are traditional in infrared photography. For infrared reflectography, however, usually a filter is employed which eliminates a little more near infrared radiation.[3] There is no need to use filters eliminating even more infrared radiation. This does not improve the results and requires a higher illumination level.

2.4 Illumination

Museums are supposed to refuse collaboration when their paintings would risk to be heated up during examination. In infrared reflectography, just as in photography, an image of the painting is obtained by registration of light reflected from the painting. To achieve this the painting must be illuminated. Much attention has been paid to reduce the illumination level necessary to obtain satisfactory infrared reflectograms with the infrared vidicon system (28, p. 53). The system can be regulated for maximum sensitivity at low illumination levels. It has been found, however, that no special measures are required when the heat generated by the illuminating light source can be sufficiently dissipated. As the areas in the painting of which reflectograms are taken, are rarely greater than c. 30 x 40 cm a small illuminating source can be used. A Philips IRK 13169X (500 W) quartz tube in an improvised half cylindrical reflector painted at the inside with aluminium paint has proved very satisfactory. The reflector is open at the sides and this allows a rapid dissipation of the heat generated by the quartz tube. More sophisticated reflectors such as used in studio-photography have been found to be far less efficient. The surface temperature of the paintings examined in this way does not rise above a usually accepted fluctuation level of a few degrees centigrade.

2.5 Monitors

For comparison with black and white photographs it is important that the reflectogram should be as sharp as possible. Unfortunately this sharpness is limited,

first of all by the number of horizontal lines displayed on the television screen. Television systems can be made not only with 625 horizontal lines as in the usual European TV-set but also with 875 lines. Reflectograms obtained with a 875 line system are indeed sharper than those made with a 625 line system (28, p. 53). However most video-recorders presently available are not constructed for storage of images with 875 lines.
When it is considered to use infrared reflectography without a videorecorder it may therefore be advisable to use a 875 line system. Most television cameras can be easily modified to operate with this system. A separate monitor is required, however, for 875 line images.

2.6 Videorecorders

The development of techniques in videorecording is quite rapid. When using a videorecorder for storing infrared reflectograms the first criterion is optical resolution. The quality of the replayed image is always poorer than the image obtained directly from the television camera. It has been found (28, p. 53) that for satisfactory results videorecorders are needed falling at least in the semi-professional class. The models on the market intended for the amateur are not good enough. Semi-professional video-recorders and -tapes are unfortunately still expensive.
With a view to the potential commercial applications much work has been done in the last years to develop various popular videorecording systems.
To facilitate exchange and diffusion of reflectograms it might well be that such techniques could be used successfully in the future. There is also the possibility that videorecorders may become much cheaper.

2.7 Tripods

A great variety of tripod-systems can be used. The choice would again depend on such variables as finances, time, occasional or regular operation, etc. In the Central Research Laboratory for Objects of Art and Science, Amsterdam, the choice has been for speed of operation and optimum height of the tripod-system at the expense of some additional bulkiness. The following options may be considered.

a. A very simple tripod, without or with a small vertical translation possibility, can be used when only smaller paintings are to be examined. When such paintings can be placed on an easel the

scanning of the picture can be achieved by translating the easel with the painting in horizontal (by pushing) and vertical direction (by handling one of the devices usually incorporated in easels). The selection of the reflectogram image is obtained by placing the tripod with the television camera at a selected distance from the painted surface. Focusing is obtained by manually adapting the lens-system of the camera.
This approach may be sufficient for occasionally using infrared reflectography under workshop conditions.

b. For the rapid examination of paintings in museums, it is an important condition that the pictures can remain on the wall. As the painting thus remains in a fixed position it becomes necessary to carry out the necessary translations with the tripod-system. A more simple tripod was used in earlier stages of the development of infrared reflectography (Cf. Fig. 5 in reference 27). An adapted tripod, normally used for photographic studiowork was employed to obtain the vertical translation. By mechanically winding a steel string the camera could be translated up and down. For small paintings the position of the camera mounted on an additional horizontal bar could be adjusted by pushing and focusing by hand. In using a zoom-lens the distance between the lens opening and the surface of the painting could be fixed at the beginning of the operation. A single further precaution must be taken, i.e. assuring that the painted surface is vertical. This is rarely so with paintings on exhibition in museums.
In actual practice some slabs of foam plastic are carefully placed between the wall and the back of the painting and the verticality of the painting is checked with a carpenter's water-level.
When the painting under investigation is not in a vertical position the focusing with larger diaphragms must be adapted over the painted surface; the reflectograms would also represent a trapezoid form of the painting and in later assembling various reflectograms would not fit properly together.
For the examination of large paintings <u>in situ</u> the use of extension pieces for the tripod is necessary. Such pieces are commercially available. Manually adjusting the horizontal position of the camera and focusing the lens becomes rather unpractical as one operator has to carry out these duties on some stable stepladder, checking his efforts with another operator on the ground watching the monitor screen. For these reasons it is then more practical

and safe to achieve the horizontal translation of the television camera in some automatic way. A servomotor with remote control has been successfully used for this purpose. Units for remote control of focusing and zoom lens position are commercially available but can also be 'home-made' with the use of servomotors.[4]
This system has been successfully used for reflectographing in situ various details of the Van Eyck Ghent altarpiece in the St Bavo Cathedral in Ghent. The television camera could be translated to about 4.5 meters allowing, e.g., the registration of some detail-reflectograms of the face of God. The main disadvantage of the tripod described is the irregular operation of the vertical translation system. This is especially awkward in moving downwards as this often occurred with unexpected jerks partly due to the unsatisfactory mechanical construction of the tripod. Such irregular movements are unacceptable when using a videorecorder, because a smooth regular movement of the scanning system is then essential.

c. In view of these considerations the mechanical vertical translation by hand was replaced by an hydraulic system. An hydraulic shaft operated by a motor on which the horizontal bar with the television camera is mounted allows a smooth and controlled vertical translation in both directions. The servomotors regulating the horizontal displacement of the camera and the zoom lens focusing and position can be controlled from the same control panel as the hydraulic shaft. The operator is therefore able to regulate position, size and sharpness of the reflectogram and is able to direct the scanning operation entirely because he can watch the reflectogram on the monitor screen when operating the controls.
This system has been used, e.g., to examine the 'Last Judgement' by Lucas van Leyden (Leyden, Museum De Lakenhal, Cf. Fig. 14 in reference 28). The drawback of the system is its relatively high weight and bulkiness. Although the hydraulic system and the shaft are mounted on wheels, allowing a rapid displacement of the system through a museum, with a view to transportation problems much lighter equipment should be developed.

2.8 Future developments

A possible direction for further development is to investigate the use of special television tubes. These may be of two kinds: a) Tubes with a similar spectral response as the infrared vidicon but a higher

responsivity. This would improve the contrast of the reflectograms and reduce even further the illumination levels; b) Tubes with a spectral response similar to lead sulphide detectors. Such tubes have been developed as prototypes and some of them have been published.[5] Preliminary experiments have been carried out by the author to investigate the possible use of thermosensitive phosphors and cholesteric liquid crystals to image reflected infrared radiation instead of emitted thermal radiation. Both systems are very cheap. The experience obtained is not encouraging, however. The sensitivity is probably too low to detect only radiation around 2.0 microns; moreover the images are intrinsically unsharp.

3. On the use of infrared reflectography in the actual examination of paintings

3.1 Preparation and operation

It is essential for a proper application of infrared reflectography that a close multidisciplinary collaboration between an art historian, a technician-operator and a scientist specialized in the examination of paintings can be realized.[6]
In planning such an investigation such a team first tries to map out the geographical and local possibilities and limitations. Although for a particular art historical problem ideally all the material of a certain painter or his school should be available, we are at present far from a reference documentation such as exists for ordinary black and white photographs (Frick Collection).
Therefore more often than not the collection of material follows a geographical pattern, governed by such factors as personnel, finances, time and, most important, the courtesy of museum or ecclesiastical authorities.
Permission is first sought to work in a particular museum or church. As it is for most human investigators preferable to work in daytime some museums are willing to allow the examination of the paintings to take place also during the regular opening hours. This is often possible outside the summer season. When such facilities can not be granted one is obliged to work outside the opening hours. Although depending on the size and the importance of the collection concerned and the hours available often a very long period is required to obtain the data in a satisfactory way: adjustments of the instruments and occasional technical trouble should be allowed for and it is often necessary to repeat the scanning of a particular painting because on reviewing it does not appear satisfactory.
Before embarking upon such a mission a survey is made

of the paintings to be investigated in the museum concerned. Black and white photographs are ordered in advance from the museum authorities and if not available it is attempted to obtain at least a photostat-copy of an illustration of each painting from the literature. A Xerox-copy of each photograph is used during the actual reflectography to note the scanning pattern and the corresponding videotape indexing.
A brief survey is made of the art historical literature, concerning such subjects as attributions, pedigree, restorations, etc. Whenever available it is of great importance to be able to study the restoration-reports of the paintings to be examined. Sometimes X-radiographs or other material of previous scientific examination exist, and is then possibly studied beforehand.
Depending on the size of the paintings an estimate is made of the amount of videotape required for a first survey-scanand an average of tapespace needed for details is calculated. For filing purposes it is preferable to allocate paintings from one 'group' [7] to the same videotape, or group of tapes.This is more practical in replaying tapes than to arrange tapes according to the provenance of the paintings. Most art historical scholars are interested in some painter and not in a particular museum collection as such.
Reproduction, cutting and editing of videotapes is very time-consuming and requires two videorecorders of the same type. Therefore when a first survey-scan has been made of a painting under investigation the members of the team watch together a replaying of the videotape and decide which details are to be taken. Notes are being made during both scanning and replaying, regarding damaged areas, cracks and obvious blackish lines on the surface liable to be confused with the underdrawing. Other particularities are also registered. A standard width is chosen for the survey-scan representing 4, 6, 8, 10, 12, 16 or 20 cm on the painting depending on the size of the painting and the amount of detail required. This facilitates interpretation of reflectograms and eliminates the need to incorporate a centimeter-scale in the reflectograms for comparison. Sometimes a preliminary scanning is realized without registration on videotape, to provide information necessary for deciding the scanning format. In scanning the painting vertically care should be taken that adjacent reflectograms in these vertical bands are positioned along the same horizontals. Otherwise later difficulties are encountered in assembling various reflectograms.

3.2 Information retrieval

In the practice of the scientific examination of

paintings it has repeatedly proven impossible to formulate all relevant questions before the actual examination takes place. It would indeed be most efficient when a 'script' could be planned on such a list of queries but this has so far appeared illusionary. Previous investigators have, e.g., attempted to select relevant details in X-radiographing the majority of paintings in a particular museum collection (18). However intelligently taken, such limited information leaves the later investigator often frustrated. Therefore the information retrieval system of infrared reflectography has so far been designed to provide a reasonable answer to future queries. This implies the choice of a format for the overall scan which provides sufficient detail to elucidate most relevant aspects of the underdrawing. Often this means that 'reconnaissance' of certain forms should be possible. The format should be not too detailed in the systematic scanning because otherwise it becomes difficult to visualize what each section represents. Sometimes infrared photographs may be successfully used in connection with reviewing videotapes, containing reflectograms. When a fairly large magnification is required to resolve the lines of the underdrawing it is often difficult to trace the 'Gestalt' of reflectograms on reviewing because vertical or horizontal bands of the painting are being displayed. In such cases it becomes necessary to present the material by making assemblies.
Videotapes can not only be displayed on larger monitor screens, such as ordinary TV-sets and professional monitors but also on monitors of such dimensions that photography of the image visible on the screen becomes possible. The means of photographing from a television (or oscilloscope) screen are manifold and the choice of possible camera-systems depends on the purpose concerned and the budget available. Two extreme cases may illustrate various possibilities. An investigator with a small budget may, e.g., wish to limit his researches to such paintings as are available in a particular museum or are presented for examination. In such cases a videorecorder may not be necessary. A simple tripod such as used in studio-photography may be used for mounting the televisioncamera and an ordinary TV-set may be used to display the image provide the camera used has a HF-output. Any photographic camera may be used to photograph the TV-image, although some experience with shutter times may be necessary. As it may be assumed that in such cases the instrumental arrangement including the painting could remain in the same place for some time, the operator could even use ordinary roll film and develop his film on the spot to judge the results. In case of unsatisfactory photographs the sequence can be repeated.

More sophisticated devices may be used for consistent results. The author has used a Tektronix C27 Oscilloscope Camera mounted through an adaptation frame onto a 12.2 x 8.9 cm monitor (Grundig BG-17). This camera can be used with Polaroid material which has the advantage of showing the result immediately but is rather expensive. However in circumstances were neither a videorecorder nor dark-room facilities are available, Polaroid film (prefarably P/N55 producing also a negative) may be the only realistic choice assuring a satisfactory record of the reflectogram. P/N55 should be used at room temperature. When used below c. 18° C. unsatisfactory negatives are obtained. Whenever it appears unlikely that the examination can be repeated it is obviously most important to be certain of tangible results.
Using a videorecorder the photography of the monitor-screen can be carried out under studio-conditions. Then it has proven to be far more economical to use a Robot Camera BE 36 using 35 mm Ilford HP 4. This camera is also adapted to the Tektronix Oscilloscope Camera. When dark-room facilities are at hand this technique allows economical reproduction of reflectograms. Due to inhomogeneity of the sensitive Pb-O-S layer of the infrared vidicon the corners may be darker on the monitor screen. This effect may be counteracted by appropriate dark-room techniques. White spots on the image are due to damaged areas on the sensitive layer of the tube; the manufacturer should select tubes for homogeneity and absence of such white spots; those otherwise appear on reflectograms.
Assembling of reflectograms is carried out by means of fitting together printed photographs of monitor screen images (the Barnes Infrared Camera originally used displayed reflectograms directly on photographic film).In order to be able to make assemblies at all, it is necessary that during actual reflectography sufficient overlapping of the areas to be reflectographed takes place. Assemblies are made by fitting together various photographs, with not too sticky Scotch tape. Cutting with a cutting machine along horizontals and verticals produces ready made pieces of this puzzle. They are in turn fitted together with Scotch tape and heatsealed on to cardboard. Removing the bits of tape produces the assembly. This can then further be photographed and handled as a normal negative. It may be obvious that assembling many reflectograms is a very tedious task. Therefore in the course of time it has been proven more efficient that the interested person familiarizes himself sufficiently with the painting and the videotaped reflectograms to be able to select really significant details. Often such details will be selected to illustrate a particular aspect of the technique of underdrawing or

a relevant modification. The corresponding numbers of the videotape are then registered and the operator is able to photograph the reflectograms requested. In the experience of the author the work required for assembling reflectograms can in this way in the majority of cases be reduced to the selection of appropriate photographs for a final report or publication.

3.3 Comparison with colour slides and infrared photographs

The most indicated method to study reflectograms is the projection of a black and white slide of a reflectogram or reflectogram assembly[8] next to a colour slide representing exactly the same area of the painting. The requirement of identical areas is very difficult to realize. In earlier stages of this research colour slides of various details were made when the painting was examined, before assembling various reflectograms. It has, however, proven to be more economical to make colour photographs of details only when black and white slides of detail-reflectograms are already available and not the other way round.
This, however, is clearly only possible when the paintings under investigation can be easily approached a second time. When this is not so, more time should be devoted on the spot to process the information contained in the reflectograms for selecting relevant material in colour for comparison. As a reasonable substitute for the above-mentioned ideal situation a colour slide of the entire painting or a part of it can be projected when reviewing the videotapes with reflectograms. After some training a critical comparison is quite possible.

The resolving power of reflectograms is poor compared with conventional infrared photographs. This is due to the fact that each reflectogram is composed of a number of lines containing a certain amount of image-points. The photographic plate contains much more information and can be 'blown-up' to a considerable extent. Television images do not provide more information on enlarging. (Children sometimes tend to sit close to the television screen to see 'more', although this does not help them really.)
Frequently infrared photographs may greatly assist the investigation of the technique of underdrawing. They are most successful in reddish and whitish areas. In some paintings infrared photographs reveal the underdrawing to a very large extent, only some greenish and bluish areas not being penetrated.
In such cases infrared reflectography is merely useful

in complementing the already available information. Sometimes these added parts of the underdrawing prove essential in the interpretation of the form and modifications. Occasionally it is found that infrared photographs reveal the underdrawing better than reflectograms in reddish and whitish areas.[9] In such cases infrared photography is a very useful complementary tool. Infrared photographs of such areas are usually taken after actual reflectography, together with the colour slides of various details.

4. Applications

4.1 Introduction

Infrared reflectography is only one of the available tools for the surface examination of paintings (24, 28, 30) and its use would be most effective in combination with data obtained with other surface examinations such as X-radiography. Often the results of paint examinations (paint cross-sections, etc.) are necessary to explain fully what is being observed in infrared reflectograms. The combined study of such various data would allow the best possible insight in the technical structure of the paintings concerned.[10] Unfortunately it is rarely possible to arrive at such a more complete survey of the technical aspects of a painting. Therefore one has mostly to be satisfied with whatever is available. A number of cases in which infrared reflectography could be usefully applied is indicated below considering the availability of infrared reflectograms (and additional infrared photographs) only. Whenever other data of scientific examination are also available they can only be an additional asset. The aim here, however, is to indicate what could be obtained by using infrared reflectography as such.

Infrared reflectography has so far been most successfully applied to fifteenth and sixteenth century European easel paintings, and it would seem indeed most effective for the examination of such paintings. Before 1970 the author has been able to reflectograph a number of Flemish Primitive paintings in various museums in Belgium and the Netherlands. The results obtained on four paintings of the Group Van der Weyden have been published (28, chapter 8.4). The examination of the Van Eyck Ghent altarpiece with infrared reflectography has been reported by the author in a study which has been submitted for publication.
Since 1970 much attention has been paid to the reflectography of fifteenth and sixteenth century Northern Netherlandish paintings. Material has been collected in reflectographing many paintings from the Groups

Master of the Virgo inter Virgines, Geertgen tot St Jans, Hieronymus Bosch, Cornelisz van Oostsanen, Aertgen van Leyden, Lucas van Leyden, Jan van Scorel, Cornelis Engebrechtsz and Pieter Aertsz. A number of paintings by Saenredam and Van Goyen has also been reflectographed. Some of this material has been published (29, 30, 31).
The most attractive way to continue the examination of paintings by infrared reflectography would be the systematic collection of data on related paintings such as, e.g., from the Group Van der Weyden. This would require, apart from the permission of the museum authorities, sufficient funds to finance travel and personnel.
Interest in infrared reflectography, however, is increasing and a number of institutions are considering or have already purchased some form of equipment. It is hoped that such dissemination will contribute to facilitate art historical work in this direction.
Apart from the examination of Earlier European paintings some other applications of infrared reflectography would seem possible. They are briefly mentioned below in section 4.2. There are, however, also limitations to the applicability of the method. A discussion of these is given in section 4.3.

4.2 Other possible applications

It has been shown elsewhere (28, p. 66) that infrared reflectography is not successful in detecting sinopia's under the intonaco of mural paintings. A drawing on the intonaco, however, could eventually be detected, but the author has not attempted this so far.
The possibility of using infrared reflectography to reveal underdrawings in illuminated manuscripts has been previously suggested (28, p. 65). A few pages of illuminated manuscripts in the Aartsbisschoppelijk Museum, Utrecht have been examined for this purpose without success. Marijnissen, however, has reported that underdrawings were visible in infrared reflectographs of the Milan-Turin Hours (20).
Infrared reflectography could therefore be used in cases where preliminary investigations with infrared photography have shown positive results.
Infrared reflectography has also been used in the Central Research Laboratory for Objects of Art and Science, Amsterdam to detect successfully underdrawings in Tibetan and Nepalese thang-kas.

Finally it may not be excluded that infrared reflectography could also be used to detect underdrawings in paintings of the nineteenth and twentieth century. Some paintings by Ingres are underdrawn (8) and Kokoschka would seem to have made underdrawings on

his paintings. Such investigations would of course only be indicated if they would serve to solve a particular problem.

4.3 Limitations of infrared reflectography

4.3.1 Introduction

Infrared reflectography has its limitations. First of all an underdrawing should be present to be revealed; it should have been made with a carbon containing pigment, be it an ink or an acqueous paint in order to be detected. An underdrawing made, e.g., with an iron-containing pigment such as an ochre cannot be detected with infrared reflectography because the ochre would become transparent in the spectral region concerned: the infrared reflectograph would see 'through' it. Another requirement is sufficient contrast between the drawing and the ground. It has been shown elsewhere (28, p. 60) that the contrast between an underdrawing made with bone black and a white chalk ground is much higher in the visible region of the spectrum than around 2.0 microns: the underdrawing and the ground both are more 'greyish' there. This in part accounts for the rather frustrating experience that, e.g., in whitish areas the underdrawing can often be observed better with the eye or in infrared photographs than with infrared reflectography. Other limits to the detection of underdrawings are set by the physical characteristics of the paint layers covering the drawing. The success of infrared reflectography is due to the fact that a paint layer which hides the underdrawing adequately for the human eye does not accomplish this when 'seen' in radiationwith a wavelength of around 2.0 microns. This hiding power depends on such characteristics as pigment/medium ratio, size and shape of the pigment particles, but primarily on the paint layer thickness. For a particular pigment and pigment/medium ratio a certain thickness of the paint layer is just sufficient to hide the underdrawing on the ground of the painting. This hiding thickness has been measured and calculated for various paints in the 0.7-2.5 micron region by the author. It could be shown that in Flemish Primitive painting paint was used economically, i.e. the paint layers on actual paintings hardly exceed the thickness required to hide the underdrawing to the human eye (28, p. 35 ff.). Therefore most of such paint layers become 'transparent' for the infrared reflectograph. However when the layers are too thickly applied this may not be so or only partially. Thus also with infrared reflectography an underdrawing may be revealed incompletely or not at all. Unfortunately one can only explain negative results fully by a

more complete examination and analysis of the characteristics of the paint layers concerned and this is rarely possible.

4.3.2 Portraits

Infrared reflectography has not been very successful in revealing underdrawings on portraits. In a number of cases no underdrawing could be detected at all.[11] Some portraits in the Group Van Scorel show a scarce indication of the main features such as lips, eyes and contours but no detailed rendering of the face.[12] It has been observed in a number of paintings with donors in the Group Van Scorel that the faces of the donors were only superficially underdrawn whereas the faces of other persons in the same painting showed a more detailed underdrawing.[13] Perhaps such a fragmentary underdrawing would either indicate the availability of preliminary studies or the intention of the Master to spend more time on the heads of the donors himself, leaving other figures to assistants.
No evidence obtained by chemical analysis for the use of metalpoint for underdrawing portraits on panels has been published so far. It is not impossible, however, that silverpoint would be 'transparent' for the infrared reflectograph although there are no experiments of calculations available to verify this. A drawing made with lead point should be detectable (28, p. 60).

4.3.3 Seventeenth century paintings

Although a certain number of seventeenth century paintings have been reflectographed infrared reflectography has so far only yielded substantial results in panels by Pieter Saenredam (29).
Sometimes infrared reflectograms allow a better insight in the technical structure of the painting because darker paint layers can be detected beneath others.[14] Discontinuities or damaged areas can also be detected. This negative result is caused by the fact that underdrawing was employed differently in the seventeenth century. Dark grounds required the use of white chalk for indicating the contours (28, p. 61) and such a drawing cannot be detected.

4.3.4 Italian paintings

Experience in reflectographing Italian paintings is limited. The paintings reflectographed so far have not disclosed much interesting material. In earlier Italian painting the underdrawing is not necessarily made with a bone black containing paint.[15] Another reason for the impossibility of revealing underdrawings could be that

on panels, especially those with much metallic foil, the first charcoal drawing was perhaps only used as a basis for making incisions, without repeating the drawing a second time with the brush (6). Evidence for this can be found, e.g., in a panel, by Niccolò di Buonaccorso, Pinacoteca Siena, Cat. 121 were in some areas the paint has disappeared. This panel has not been examined but it would seem that the dark lines visible in the folds are not an underdrawing but rather dark paint which remained in the incisions.
In reflectographing a 'Madonna and Child' by Fra Angelico in the Rijksmuseum, Amsterdam (Cat. 17 B1) the only darker lines visible in the reflectograms did exactly correspond with incisions.
An improvement in the detection of underdrawings in Italian paintings is to be expected in paintings giving already good results with infrared photography.[16] Interesting results are also to be expected in, e.g., paintings from the Group Cosimo Tura, notably in the centre panel of the Roverella altarpiece (National Gallery, London, Cat. 772) where the underdrawing can be seen with the naked eye in some areas.[17]
The 'Madonna, St John and Angels' (National Gallery, London, Cat. 809) attributed to Michelangelo was shown by chemical analysis to have a carbon black underdrawing (H. Ruhemann and J. Plesters, 'The Technique of Painting in a "Madonna" attributed to Michelangelo', Burlington Magazine, 106 (1964), 546-554).
Italian paintings on canvas occasionally show a blackish underdrawing in some areas. The 'Christ and the woman taken in adultery' by Tintoretto (Rijksmuseum, Amsterdam, Cat. 2302 E2) has a black underdrawing of the architecture, visible partially with the naked eye. This drawing has been revealed more completely by infrared reflectography. Miss Joyce Plesters has kindly drawn the attention of the author to a black underdrawing revealed by infrared photographs in the robe of Magdalene in Tizian's 'Noli me tangere' (National Gallery, London, Cat. 270). Underdrawings on Italian paintings on canvas may perhaps be shown to occur more frequently upon investigation.

4.4 Attribution problems

Perhaps the most tempting application of infrared reflectography would seem to be a reappraisal of the situation with regard to attributions of fifteenth and sixteenth century paintings. In many decades of connaisseurship and scholarly contributions an impressive framework of attributions has been built. However these structures are resting on but a few pillars: paintings whose authenticity and authorship can not be questioned are usually taken as a nucleus. Around this kernel, then, various strata of other

paintings are arranged both on stylistic and historical grounds. The terminology 'Group' is therefore a most realistic one (Cf. note 7). J. Folie (10) has shown how weak such foundations may be. Using the availability of archival sources, literary documents and signatures as criteria for authentication, not more than forty works of some four thousand five hundred known fifteenth century Flemish paintings could be retained. The situation in other earlier European schools of painting is possibly quite similar. Even when a painting may be considered to be satisfactorily authenticated this by no means implies that the painter himself was responsable 'for each brushstroke' as Dürer stated with regard to the Heller-altarpiece (24). The problem may be complicated by one painter leaving the painting unfinished, its being terminated by another painter. The Ghent altarpiece and the 'Justice of Emperor Otto' panels in Brussels are examples of paintings solliciting a 'separation of hands'. Infrared reflectography may contribute here. The problems related to workshop practice may perhaps also be somewhat disentangled by infrared reflectography.
Some of these aspects are briefly discussed below.

4.4.1 Grouping around authenticated paintings

Theoretically one could consider the underdrawings of historically authenticated paintings as a starting point for a new and perhaps different arrangement of paintings in groups. This approach is based upon the hypothesis that underdrawings are always by the hand of the 'Master'. Such a hypothesis, however, is probably much better than the one used in the more common practice, i.e. that the visible surface of the paintings is (mainly) by the Master's hand.[18]
The geographical scattering of authenticated paintings in one group makes this approach, although most elegant, rather difficult.
A first attempt in this direction using infrared reflectography has been made with regard to three works, now in the Lakenhal Museum, Leyden (Cat. 93, 94 and 622),and mentioned by Carel van Mander as by Cornelis Engebrechtsz (1468-1533).
A number of other paintings usually placed in the Group Engebrechtsz could also be examined in various Dutch museums. A description of this work has been prepared for publication.[19] Another authenticated painting the 'Last Judgement' by Lucas van Leyden also in the Lakenhal Museum has been extensively reflectographed with some other panels usually attributed to Lucas van Leyden in Dutch museums. This material is at present being studied by J.P. Filedt Kok.
It would seem that further efforts in this direction

might prove rewarding. The author believes that some paintings will as a result of such investigations tend to shift to the periphery of the 'Group' in question, or rather drop out altogether.

4.4.1.1. Group Van Eyck

The Ghent altarpiece has been reflectographed with the Barnes Infrared Camera in 1966 and in 1969 with the infrared vidicon television system in close collaboration with the Institut royal du Patrimoine artistique. Interpretation of the reflectograms was facilitated by other existing data collected by the Brussels Institute during the 1950-51 restoration of the 'Mystic Lamb'. The modifications thus observed in the Ghent altarpiece belong mainly to three groups: those achieving a greater three-dimensionality, those correcting iconographically incorrect or unrealistic renderings in the underdrawing (Fig. 1) and those affecting the green vegetation.
Although only two other paintings in the Group Van Eyck have been reflectographed some infrared photographs exist of other Eyckian paintings and an attempt has been made to review the Hubert/Jan problem in relation to the underdrawings. In the personal opinion of the author the evidence available does not necessarily hint at the presence of two masters (Cf. note 10).

4.4.1.2 Group Van der Weyden

A limited number of paintings in the Group Van der Weyden has been reflectographed. They are perhaps not very typical and a description of the various characteristics should therefore be considered as incomplete, unsatisfactory and only a preliminary attempt to make the material available (28, p. 68 ff.). As infrared photographs of paintings from the Group Van der Weyden are scarce or inconclusive (15, 32) very little can be done before the key paintings (many of them in the Prado Museum) have been examined. Although the underdrawings revealed so far are quite interesting and raise a number of questions it would seem that further research into, e.g., the Rogier van der Weyden - Master of Flémalle problem (Cf. also section 4.5.4.1) could only proceed when material from Spain has become available.

4.4.1.3 Group Memling

In a penetrating analysis of underdrawings such as revealed in infrared photographs of three paintings in the Group Memling, Taubert (24, p. 113-118) has described some characteristic aspects of the drawing

technique of this painter:

' Bei Memling ist zu Beginn der Arbeit am Gemälde noch keine feste Bildvorstellung für die Einzelform vorhanden. Das Werk setzt sich aus immer neu einsetzenden schöpferischen Bemühungen um die Einzelform zusammen.'...

' Die unterzeichneten Formen werden ..... so oft und stark verändert, dasz endlich schräge Arbeitschraffuren zur Anzeichnung des Formzusammenhangs notwendig sind.....'

' Die Hände anderer Personen zeigen ebenfalls mehrfache Veränderungen, teilweise schon innerhalb der Unterzeichnung'.(24, p. 114)

' Die schöpferische Anspannung durchläuft hier kontinuierlich sämtliche Malschichten.' (24, p. 117).

These characteristics can be recognized in the underdrawings as revealed by reflectograms taken from the altarpiece with 'God and music-making angels' in the Antwerp Museum voor Schone Kunsten (14, No. 22).
Some of the hands of the angels may serve as typical illustrations of what Taubert has described (Fig. 2).
Białostocki (3) has recognized and discussed these characteristics in the Danzig altarpiece of the 'Last Judgement' (14, No. 8).
The only other painting from the Group Memling reflectographed so far by the author is the fire-damaged centrepiece of a 'Lamentation' in the Museum Boymans-van Beuningen, Rotterdam (14, No. 6).

4.4.1.4 Group Van Scorel

Paintings of the Group Van Scorel presently located in the Netherlands have been reflectographed fairly completely and extensively. The painting in the Church of our Lady in Breda has not yet been examined. Material from important paintings outside Holland such as the polyptych of Marchiennes, now in Douai and the early Frangipani triptych in Obervellach, Austria is still lacking.
The available reflectograms and infrared photographs of paintings in this group would possibly allow both a grouping around reasonably authenticated works and an attempt to draw a chronology of the underdrawings as such.[20]

4.4.2 Other possibilities to arrange underdrawings

The systematic approach of starting with the investigation of underdrawings in authenticated paintings, however desirable, is not always possible due to geographic and other obstacles. Frequently therefore one is forced to 'do' something with the available material without very solid reference points.
It may, e.g., be attempted to analyse the various

characteristics and the stylistic aspects of the underdrawing. The rôle of contours, hatchings and other means of indicating volume may be considered. Such particulars as the way in which trees, landscapes and architectural elements are either or not underdrawn can also be useful.
The format, not only of the painting itself but also of the various figures in different 'plans' of the painting should be taken into account.
In some instances the characteristics of the underdrawings are so typical that when they are recognized in various paintings these may be grouped together with some confidence. When possible the linking of such a sub-group to an authenticated painting, may then further establish the authorship more firmly. The example from the Group Memling given in section 4.4.1.2 would seem to fall in this category.
Suggestions for further investigations may be found, e.g., in the characteristic underdrawing of a painting by the Master of 1518 (Stuttgart, Staatsgalerie, inv.no. 2684; 1, p. 175, Cat. 98) as published by Heiber (16) and partially visible with the naked eye. A great number of paintings has been grouped around this anonymous Master and a systematic study of underdrawings might well contribute to this problem. The Antwerp manierists and the anonymous masters of the fifteenth and sixteenth centuries in general would indeed form a most interesting field for the application of infrared reflectography.
A very characteristic underdrawing has further been revealed by infrared reflectograms of a Pietà usually ascribed to the Master of St Sebastian (Antwerp, Museum voor Schone Kunsten, Cat. 5037; 22, No. 261, p. 232). A comparison with the panels now in the John G. Johnson Collection, Philadelphia (22, Cat. 258, p. 232) from which the temporary name of the Master is derived would obviously be most interesting.
It would seem that in judging the characteristic aspects of underdrawings, due attention should be paid to the way in which the underdrawing of the background landscape and architecture is handled. Two examples may illustrate this. The first is the background in a Pietà, usually attributed to Petrus Christus (Musées royaux des Beaux-arts, Brussels, Cat. 139) and described by Friedländer (12, p. 88) as 'unique in the Master's oeuvre'. It would be desirable to investigate by comparison with infrared reflectograms of the background in other paintings in the Group Petrus Christus (notably the 'Lamentation' in the Metropolitan Museum, New York, Cat. 91.26.12) whether the underdrawing of the trees and houses is also 'unique' or rather a 'regular' aspect of Christus' underdrawing style.
In the Brussels' 'Lamentation' most trees have not been underdrawn; a few of them are, however, especially in

areas with architecture. There are two drawn horizons in this painting; minor displacements and modifications occur between the underdrawing and the painted surface.
The underdrawing in the background of an 'Adoration of the Magi' in the Group Geertgen tot St Jans (Rijksmuseum, Amsterdam, Cat. 950 A1) would also seem to be rather typical (Cf. 26 and 28 Fig. 17). The attribution of this painting has been questioned, the landscape has even been attributed to the Master of the Brunswick triptych. A comparison with the backgrounds in the paintings in Vienna (13, No. 6A, 6B) which are attributed without much difficulties to Geertgen would be interesting.[21]
It may be observed here that a comparison between the underdrawing in the background elements and in the larger figures with their draperies may not be easy or straightforward.

4.4.3 Chronology

Chronological sequences of paintings are usually constructed on the basis of dated paintings or written sources mentioning both a particular painting and a date. Uncertainty may be caused by dubious authenticity of the date on the painting or frame and by ambiguity in the description of the painting concerned. Stylistic considerations play an important rôle as well.
Clearly the visible surface of the painting is the point of reference here. In taking the underdrawing as an independent element in the construction of a chronological sequence the stylistic approach is obviously also of paramount importance. One should be able on the basis of dated paintings to use their underdrawings as reference points. Possibly then 'early', 'intermediate' and 'late' underdrawings could be recognized.
So far an attempt to arrange underdrawings in a chronological order has only been made for a number of Engebrechtsz' paintings(Cf. note 18).

4.4.4 Comparison of underdrawings with independent drawings of the same artist

The comparison of underdrawings with independent drawings ascribed to the same artist could be another approach. Such autonomous drawings are scarce before the middle of the fifteenth century in the North of Europe.
More material is available from the beginning of the sixteenth century.
J.P. Filedt Kok has studied drawings from the Group Hieronymus Bosch and has compared these with underdrawings as made visible in infrared photographs and

reflectograms of paintings from this Group. A correlation seems to be possible (9).
Infrared reflectography of the very large triptych the 'Last Judgement' by Lucas van Leyden has revealed a beautiful underdrawing under most of the painting.[22] Shadows are not only indicated by firm, modelling hatchings but also by washing. Typical is also the presence of many dots belonging to the underdrawing (Fig. 3).
The underdrawing of the outside shutters deviates in many aspects from that on the inside of the triptych (Fig. 4).
A correlation with the drawings and etchings either signed or attributed to Lucas van Leyden with the underdrawings is being attempted by J.P. Filedt Kok. The typical style of the underdrawing in the Leyden altarpiece defeats, however, a direct comparison with existing drawings from the Group Lucas van Leyden.

4.5 Workshop methods

4.5.1 Introduction

Very little has been transmitted through literary sources about workshop methods in the fifteenth century. Occasionally hints are to be found such as in the lawsuit against Albrecht Cornelis (34) and the dispute between Gerard David and Ambrosius Benson.
In the sixteenth century such information is perhaps somewhat less rare (Cf. the information about Frans Floris in reference 11).
Taubert (24) has extensively discussed various aspects of mediaeval workshop methods, and paved the way for a useful application of scientific examination of paintings in this respect.
It is rather difficult to search in a systematic way for elements in the paintings themselves which could throw new light upon this matter. However, infrared reflectography may contribute to collect more information. A number of possible directions for further investigations and some observations distilled from the work done so far are given below.

4.5.2 Methods of transfering preliminary drawings

Methods of transfering preliminary drawings have been discussed by Taubert (24) who gave some examples of the use of punched cartoons (Cf. section 4.5.4.3).
Taubert also suggested the use of a pantograph in making exact copies. Such an instrument would allow to transfer the original form into a different format. No examples have been encountered so far by reflectography but examination of, e.g., the two versions of

the 'St John' altarpiece of the Group Van der Weyden in Berlin (each panel 77 x 48 cm) and Frankfurt (each panel 44 x 27 cm) could be most interesting.
Another tool is the use of a grid of squares both on a preliminary drawing on paper and on the ground of the painting.
A number of paintings attributed to Pieter Aertsz in the Rijksmuseum, Amsterdam, and the Museum Boymans-van Beuningen, Rotterdam has been reflectographed. Three of these paintings, all panels, showed not only an underdrawing but also a grid of squares on the ground. The painting representing the 'Seven Sorrows of the Virgin' in the St Leonard church, Zoutleeuw, Belgium shows similar grids of squares which can be observed partially in ordinary light.[23] In the same church the 'Seven Sorrows' triptych is preserved, also by Pieter Aertsz. A squared-up drawing in the Staatliche Graphische Sammlung, Munich is a study for the scene on the exterior left hand shutter depicting 'St Martin and the Beggar' (5). With the eye no underdrawing or grid of squares can be detected in this altarpiece, but reflectography of this panel would be most interesting.

4.5.3 Division of labour

In workshops some division of labour must have existed between the Master, the assistants and the apprentices. Existing evidence from literary sources and technical possibilities have been discussed by various authors (21, 24, 28). Infrared reflectography may contribute to investigate this problem. Two aspects are briefly mentioned below.

4.5.3.1 Different treatment of outside shutters in altarpieces

In reflectographing many NorthernNetherlandish altarpieces it has so far in three instances been observed that the underdrawing of outside shutters was of a different and inferior quality as the one on the inside of the same altarpiece.[24] This may perhaps be indicative of assistants also collaborating in making underdrawings.

4.5.3.2 Script on the white ground of panels

Aullmann (2) has drawn attention to the occurence of colour indications on the white ground of panels by Conrad Witz. The colour or pigment to be used, perhaps as a hint for assistants, are indicated on the appropriate area in the underdrawing. Such colour indications seem to occur not infrequently.[25] It would seem, however, that such indications were not only

used for colours. The author has found an almost identical three letter sign two times in reflectographing the Memling panels in the Antwerp Museum (14, No. 22), each time on the left-hand edge of a plank making up the panel and apparently unrelated to the colour of the robes covering the letters. Some letter signs have been revealed by infrared reflectography on the ground of the Lucas van Leyden 'Dance around the golden calf', Rijksmuseum (Cat. 1452 A2). It is extremely difficult, however, to read these signs. Signs have also been found in reflectographing a painting of the Master of the Manna, 'Offering of the Jews' in the Rotterdam Museum Boymans-van Beuningen (Cat. 2349).
The observations in portraits (section 4.3.2) may also hint at some division of labour.

4.5.4 Copies

4.5.4.1 Introduction

It would seem that infrared reflectography might be rather useful in the investigation of similar versions of the same painting. Usually such versions are called 'copies' but this term appears to have an unfavourable emotional value. A more refined terminology is also important from a systematic point of view. Various scholars have dwelled on this subject among them Schöne (23) and Taubert (24, Chapter 10). The terminology used by Taubert would seem to be the most appropriate. A copy is defined as a faithful imitation of an example ('gegenstandsgetreue Nachahmung eines Vorbildes') and divided in two classes
1) creative copies
2) exact copies.
Paintings in the first class follow the iconography of the example partially or completely, but do not imitate the artistic form of the original. This class includes paintings in which some groups or figures are copied but other parts painted quite differently as in the example (Cf. section 4.5.4.4).
The methods used to transfer such partial elements may be studied using infrared reflectography (Cf. 4.5.2).
More interesting in the present context, however, are the exact copies. This class includes paintings in which the example has been imitated on a different scale keeping the same proportions. Various methods to obtain such an enlarged or reduced image have been discussed by Taubert (24). The investigation of underdrawings in exact copies of the fifteenth and sixteenth centuries is particularly challenging because in such copies it is not straightforward to decide how they were created. Supposing that of two identical paintings

one is the example and the other the imitation, it should then be theoretically possible to decide this issue by comparing the two underdrawings. One would expect in the original a certain creative development between the underdrawing and the final paint layers, but the imitation would have started from the surface of the finished painting. In the exact copy the painted surface would have been reproduced without a knowledge of the underdrawing of the original. The situation becomes more difficult when it can not be established that one of the paintings is indeed the original example (Cf. the 'Miraflores' altarpiece problem, 24). Further it may not be taken for granted that an exact copy was always made when the example was already finished. This may complicate the matter allowing for gradual transitions between exact and creative copies. Unfortunately very little is known about workshop practice in the fifteenth and sixteenth centuries (28, p. 77). It is one of the aims, however, of a systematic application of infrared reflectography to find new clues in this respect.
Therefore a number of observations is discussed below either suggesting further work, adding questionmarks or hinting at possible explanations.

4.5.4.2 Group Van Scorel

Two copies exist of the panel in the Rijksmuseum, Amsterdam (Cat. 2189) representing Mary Magdalene seated in a landscape: one on loan to the Courtauld Institute of Art in London, the other in the Museo Nazionale in Palermo (4). The Rijksmuseum painting is extensively underdrawn except for a strip on the top. This strip was supposed to be an addition by Bruyn (4) because it is missing in the copy in Palermo. The fact that no underdrawing could be detected with infrared reflectography in this strip and the appearance of a discontinuity in the X-radiograph of that area would confirm this hypothesis.
The underdrawing is partially visible with the naked eye.[26] There are many significant modifications, notably in the face, the robe and the albarello.
An investigation of the underdrawing in the two copies would perhaps allow to decide whether the copy was made with a knowledge of the original underdrawing, i.e. in the 'workshop' of the Master, or on the basis of the finished painting only.

4.5.4.3 Group Gerard David

Cartoons and tracings appear in the second half of the fifteenth century in Italy as tools for the transfer of elements in mural paintings (21). Italian drawings punched to serve as cartoons are not rare (24, p. 150).[27]

In fifteenth and sixteenth century painting in the North so far evidence of such methods of transfer has only been found in the Group Gerard David. Taubert (24, p. 153 ff.) has discussed some examples and Arndt has shown the use of tracings in the Munich 'Adoration of the Magi' (14, No. 181). A further example of the use of partial tracings is to be found in the predella of the altarpiece of 'St Anne' (14, No. 167). Infrared photographs show that a tracing has been used for the sheets of the bed with the three children and for the heads of the children in the tub. The position of the sheets has, however, been modified in the final paint, but the contours of the boys in the tub have been followed.[28]

The characteristics of underdrawings in this Group as far as can be judged from the available material would seem to be a careful sfumatolike indicating of faces and hands and fairly extensive hatchings to indicate form and volume.

Comparison with the underdrawing revealed by infrared reflectography in the dark blue robe of the Madonna in the 'Rest on the Flight into Egypt' (Antwerp, Koninklijk Museum voor Schone Kunsten, Cat. 47) shows that in that copy (14, No. 212b) all the linear contours are underdrawn precisely as in the Prado panel (14, No. 212) but without any indication of shades by hatchings (Cf. Fig. 7 in reference 27). This could be indicative of a copy made directly from the original because apparently no further help was required to paint the shadows.

4.5.4.4 Group Master of the Figdor Deposition

An attempt has been made to compare two paintings in this Group: the 'Crucifixion' in the Rijksmuseum, Amsterdam (13, No. 28) and a 'Crucifixion' in the Aartsbisschoppelijk Museum, Utrecht (13, No. 29). Although not exactly alike in its entire composition, many figures are very similar in the two paintings. It could be presupposed that some form of cartoon would have been used as these figures (Mary, St John, horses, etc.) have almost identical dimensions. Infrared reflectography did not reveal anything like an underdrawing in both paintings. It could be that the copies were made outside the workshop with the use of partial drawings of some of the figures ('exempla') and a sketch or reminiscence of the overall composition.

A planned comparison with the underdrawing of the 'Martyrdom of St Lucy', Rijksmuseum, Amsterdam (13, No. 27) could thus not be attempted. The underdrawing in this painting could only be revealed partially.

Conclusions

In this survey some technical aspects of infrared reflectography have been discussed against the background of an increased practical experience in recent years. Those who will use some form of equipment may perhaps profit from this. It is to be expected that the work involved in photographing and assembling reflectograms may well hamper extensive use of the method. It is still not exactly a 'push-button' method to be easily employed by the interested art historian. However, collaborarion between those possessing some sort of equipment and exchange of material may well prove to be rewarding.
The best way to apply infrared reflectography in art history is certainly to collect data from geographically scattered paintings with a view of contributing to the study of a particular art historical problem. A systematic study of paintings in the Group Hieronymous Bosch and those related to the Van der Weyden/Flémalle problem would be a case in point.

Acknowledgements

Recent developments in infrared reflectography as described in this report are almost exclusively due to the very close collaboration between G.J.A. Kooiman, J.P. Filedt Kok and the author. The continuity in this teamwork even under difficult circumstances has been extremely appreciated. The author is very grateful for their many-sided support.
The directors of the Rijksmuseum, Amsterdam, the Museum Boymans-van Beuningen, Rotterdam, the Museum 'De Lakenhal', Leyden, the Centraal Museum and the Aartsbischoppelijk Museum, Utrecht, the Frans Hals Museum, Haarlem and the Central Research Laboratory for Objects of Art and Science, Amsterdam, are to be thanked for facilitating the development of infrared reflectography since 1970.

Fig. 1

Infrared reflectogram of a detail in the panel with music making angels in the Van Eyck Ghent altarpiece showing the hand of the harp-playing angel tapping the shoulder of the angel playing the alt-tenor fiddle. In the painting the shoulder is lower, the palm palm of the hand consequently longer and the index and middle finger somewhat lower.

Fig. 2

Infrared reflectogram of the hand holding the bow of an angel playing the fiddle in the panel Cat. No. 780 in the Koninklijk Museum voor Schone Kunsten, Antwerp. This panel is one of three paintings representing 'God and music making angels' and is usually attributed to Memlinc. The searching way of positioning the hand with various modifications in the underdrawing itself is typical of Memlinc.

Fig. 3

Infrared reflectogram of the outstretched hand of a prostrated woman in the foreground of the centre panel of the 'Last Judgement' by Lucas van Leyden in the Museum 'De Lakenhal', Leyden. The 'washed' underdrawing with many dots is characteristic of the interior of this triptych. Magnification c. 1.5x.

Fig. 4

Infrared reflectogram of the right hand of St Paul in the right hand exterior wing of the Lucas van Leyden 'Last Judgement' triptych, Museum 'De Lakenhal', Leyden. The stylistic differences with the underdrawing shown in Fig. 3 are rather striking.

Fig. 5

Reflectogram of the right hand of the Holy Woman embracing the Cross in the centre panel of the 'Crucifixion' by Cornelis Engebrechtsz (Museum 'De Lakenhal', Leyden, Cat. 93). The hand has been made slightly smaller during painting, the blackish inner lines at the middle and right finger represent in fact paint. The hatchings across the fingers and those modelling the hand are rather typical of Engebrechtsz. Magnification c. 2x.

Fig. 6

Infrared reflectogram of a detail in the panel 'Christ Bidding Farewell to his Mother', Rijksmuseum, Amsterdam, Cat. 905 A1, usually attributed to Cornelisz Engebrechtsz. The characteristic hatchings across the fingers and the modelling in the underdrawing would support this attribution. Magnification c. 2x.

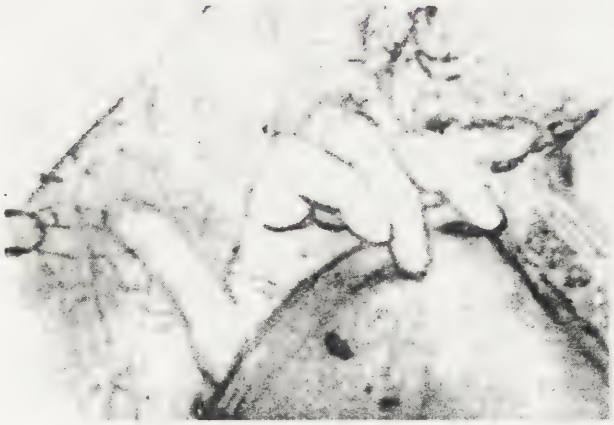

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Notes

1. This has been proved by measurements carried out by the author (28). Preliminary results in detecting underdrawings under greenish areas in paintings had been obtained and published previously (25). The measurements referred to indicate that there is no sense in using detecting systems optimalized for detection in other areas of the spectrum to obtain better images of underdrawings.

2. The use of a lead sulphide detector with maximum response at 2.0 microns allows optimum penetration of paint layers in combination with a high responsivity requiring low illumination levels (28, p. 49).

3. Kodak Wratten 87A, cutting on at 0.9 microns, i.e. only radiation longer than 9000 Å is transmitted.

4. B.L. Veen of the Central Research Laboratory for Objects of Art and Science, Amsterdam made a beautifully operating prototype of the latter class. Facilities have to be provided for preventing inductive interference with the image on the monitor screen.

5. Cf. F. Desvignes, 'Problèmes et techniques de la télévision en infrarouge', Acta Electronica, 7 (1963), 295-318.
Dr A. Bril of Eindhoven has very kindly tested the potentialities of one of such tubes, a 'tube saphir' developed at the Laboratoires d'électronique et de physique appliquées in Limeil-Brévannes, France for infrared reflectography but the results were not encouraging. Possibly the responsivity of this tube did not extend far enough.

6. A team consisting of J.P. Filedt Kok, G.J.A. Kooiman and the author has successfully operated at the Central Research Laboratory for Objects of Art and Science, Amsterdam, between February and August 1971. Much of the material presented in this report is the result of this collaboration.

7. In accordance with the terminology introduced by the Centre national des Recherches 'Primitifs Flamands', Brussels.

8. Such slides are, e.g., obtained by photographing prints of reflectograms or reflectogram-assemblies with Agfa Dia-Direct 16° DIN film, which produces projectable diapositives in black and white.

9. Beneath layers consisting of lead white and vermillion infrared reflectography does not reveal underdrawings much better than conventional infrared photography. Depending on such factors as pigment/medium ratio, layer thickness, etc. the improvement is not more than about 20%, i.e. that a layer 1/5 thicker can just be penetrated by infrared reflectography operating in the 2.0 microns region of the spectrum. Further measurements of optical parameters required to predict the hiding thickness would be required in the 6000-10000 Å region of the spectrum to obtain a more satisfactory explanation.

10. This has been systematically attempted by the author for the Ghent altarpiece (J.R.J. van Asperen de Boer, The Ghent Altarpiece Re-examined, manuscript submitted to the Centre National de Recherches 'Primitifs Flamands', Brussels.)

11. E.g. in the 'Portrait of a Pupil' (Jan van Scorel), Museum Boymans-van Beuningen, Rotterdam, Cat. 10.

12. E.g. the 'Portrait of a Man', Rijksmuseum, Amsterdam, Cat. 2196 A3.

13. E.g. the head of a donor in a panel from the St Vitus-church Hilversum, the Netherlands now in the Aartsbisschoppelijk Museum, Utrecht and in the faces of four donors in the Lochorst triptych, Centraal Museum, Utrecht, the Netherlands, Cat. 256. Both paintings belong to the Group Jan van Scorel.

14. This has been found to be the case in reflectographing Rembrandt's 'Saul listening to David playing on the harp' Mauritshuis, the Hague, Cat. 621. The dress of David shows a dark underpainting in the reflectograms.

15. The author has observed that in a panel ascribed to the Master of San Francesco in the Lehmann collection, New York, a brownish underdrawing was visible in a small area where the paint layers had scaled off.

16. Cf. for instance the infrared photographs of the Maestà by Duccio as published in the Boll. dell' Ist. Centr. del Restauro, 37-40 (1959), Tav. XXV and Tav. LIV.

17. An infrared photograph of an angel's head from this painting, showing an underdrawing, has been published by W.G. Constable, The Painter's Workshop,

Oxford University Press, London 1955, Plate XV (b).

18. Early Netherlandish paintings on panel are usually built up by a varying number of paint layers. The problem of how this creative process is carried out and to what extent the Master's hand is to be found in the layers between the underdrawing and the surface of the painting belongs to the intricacies of workshop practice.

19. J.R.J. van Asperen de Boer and A.K. Wheelock Jr, 'An Investigation of Underdrawings in some Engebrechtsz' Paintings'. Manuscript submitted to the Editor of the Art Bulletin. The authors show that on basis of a comparison of underdrawings the usual attribution to C. Engebrechtsz of two panels in the Rijksmuseum, Amsterdam (Cat. 905 A1 and 905 A2) can be confirmed (Figs. 5 and 6).

20. It is hoped that this material will be evaluated in the course of 1973 by Miss Molly A. Faries.

21. Infrared reflectography of paintings in this Group located in the Netherlands has so far been inconclusive. The 'Holy Kinship' (Amsterdam, Rijksmuseum, Cat. 950) is much damaged, an underdrawing has only been made visible in the architecture. The much-debated 'Tree of Jesse' (Rijksmuseum, Amsterdam, Cat. 950 A2) is hardly penetrable. No underdrawing could be revealed in the Utrecht' 'Man of Sorrows' (13, No. 7). The 'Virgin and Child with angels' (Rotterdam, Museum Boymans-van Beuningen, Cat. 2450) showed a regular underdrawing in the Virgin's robe.

22. The clouds in the intermediate plane can not be penetrated because of blackish underpainting in this area.

23. Professor Dr J.K. Steppe of Louvain, Belgium has first made this observation (personal communication) which was confirmed by the author. The medallions in this triptych show smaller squares than the rest of the painting.
The use of a grid of squares on the ground of the panel in connection with a squared-up preparatory drawing would not seem to be unique. In two panels by Pieter Saenredam such a grid has been found by infrared reflectography (29). Theoretically the possibility of an assistant carrying out the underdrawing on the panel guided by the squared drawing of the artist may not be excluded.
In the paintings in the Group Pieter Aertsz examined so far there is no indication, however, to

suggest two different hands.

24. Lucas van Leyden, 'Last Judgement', Leyden, Museum 'De Lakenhal', Cat. 244 (Fig. 4); Cornelis Engebrechtsz, 'Crucifixion', Leyden, Museum 'De Lakenhal', Cat. 93; Group Van Scorel, two shutters of an altarpiece, formerly Hilversum, St Vitus church, now Aartsbisschoppelijk Museum, Utrecht.

25. J. Taubert (personal communication) has collected evidence of this and is preparing an article on the subject.

26. This apparently disturbed earlier spectators because in 1806 a restorer obliterated '... Al de zwarte doorgeslagen stippels over de geheele tronie en hals ...' (17, p. 101). His retouches are now somewhat discoloured and show up whitish.

27. More exceptional is the Raphael 'Allegory', National Gallery, Cat. 213 a painting for which the punched cartoon has also been preserved (National Gallery, Cat. 213A). Infrared reflectography of the painting could perhaps contribute to the problem of whether the carbon particles used in the transfer were reinforced into a real underdrawing (Cf. 24, p. 156).

28. This would confirm the observation of E. von Bodenhausen, Gerard David und seine Schule, Munich 1905, p. 171: 'Im übrigen aber steht die Mitarbeit eines oder mehrerer Gehilfen, besonders für die Predellenbilder ausser Frage ..... Am deutlichsten verrät sich die ungeübtere Hand in der des Meisters ganz unwürdigen Modellierung der drie Knaben im Kübel'.
Such an exact following of the contour of the underdrawing may thus hint at the activity of a less creative assistant.

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Committee for Conservation

Conseil International des Musées
Comité pour la Conservation

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SCIENTIFIC EXAMINATION AND CONSERVATION OF ETHNOGRAPHICAL OBJECTS
THE SITUATION AT THE ETHNOLOGICAL MUSEUM IN VIENNA

I. Introduction

The subject on which I am to speak is of general importance to conservators of ethnographic collections. For the newly founded "Patrimoine Ethnographique" I think it will be most helpful to review what possibilities exist at the Ethnological Museum in Vienna for the examination of ethnographic objects, which goals we have in doing so and what guidelines are followed, as well as to give a conspectus on conservation, which we have endeavoured to carry on in a scientific way for some time.

The possibility of having scientific examinations and proper conservation of ethnographical objects carried out by professional, specially educated persons exists for only about ten years. The evolution of the Ethnological Museum(1) was not easy. Its presentation is necessary for understanding the present situation. Originally, the Ethnological Museum formed part of the "Anthropological-Ethnographical Department" of the Museum of Natural History as the "Ethnographical Collection"; due to limited space it was moved in 1927 to the first floor of the Ring Street tract of the New Hofburg and set up as an independent scientific collection (under the sign MfV on 25 May 1928). During the last war most of the collection was hidden; a hospital which had been

bombed had to be moved into a majority of the show rooms. This was a very unfortunate situation for such a significant ethnological collection and lasted until 1956.

The Ring Tract of the New Hofburg in which the Ethnological Museum is now contained was originally intended as private quarters for the Kaiser and his family but was in fact never used as such. Already in 1901 this part of the splendid building of the New Burg was partly and since 1907 - through the initiative of Archduke Franz Ferdinand - entirely used as a museum. Using present, modern standards the premises were however not at all ideal for housing a museum. This particularly applies to the technical spaciousness, the installations and the store rooms. It was necessary to come to terms with installing a chemical laboratory, a restoration workshop and other technical furnishings in this prescribed situation. General conservation measures for the protection and preservation of the collection are also made more difficult by this situation. However, such difficulties are faced in other museums of the world, which do not have the good fortune of having a new house from the very beginning or the possibility of planning.

Furthermore, the care, conservation and restoration of the objects lay earlier in the hands of more or less unschooled, unknowing personnel. This refers generally to the situation in this field when the practice of conservation was not yet touched and stimulated by the findings of the natural sciences. Therefore, it was almost completely dependent on the attitude of the person, on his serious striving and will to adopt autodidactic, empirically founded knowledge, how responsibly and successfully the restoration was performed. The art of restoration was usually carried out as a secret science, methods were not revealed and usually carried to the grave. This situation may have been very similar elsewhere.

II. Facilities for Examination and Conservation

In 1960 a chemical laboratory was installed, and a few years later a restoration workshop was built. Both are manned by a chemist, who is also a graduated ethnologist, and an academic restorer. Due to personnel policy and budgetary reasons it has not been possible to enlarge the staff. This would be desirable in view of the steadily increasing laboratory examinations and especially for the restoration department. Particularly in an ethnographical museum of the size of ours the most varied types of materials fall to restoration. It is a great advantage to have a restorer specialized in the most important material classes, such as stone and ceramics, wood and organic materials, such as paper and bone, etc., metals and textiles. Each of these groups of materials demands special skill and treatment.

III. Exhibition and Storage Conditions

As already noted, the premises of the museum do not meet the ideal standards which would be required. This applies particularly to the store rooms. Only about four per cent of the entire collection can be exhibited in the show rooms. The rest is stored in rooms in the basement, in the few store rooms on the first floor and in the cupboards and drawers below the show cases.

For proper preservation of the collection pieces it is extremely important to control the environmental conditions, since they can be the fundamental cause of damage and deterioration of ethnographical objects(2). Of great importance in this connexion is the degree and fluctuation of the relative humidity. A too low and strongly fluctuating humidity is very bad for objects of wood, bark, ivory - in other words, for any organic material. Objects of this type usually come from areas with a high humidity and must be very slowly acclimated to the museum. They may never be stored too dry; otherwise, with wood

and ivory for example, cracks result. Objects made up of diverse materials are particularly sensitive to abrupt changes in humidity because their components may react quite disparately. The illustrations of the Guatemalen cult mask, which had been repainted several times for rituals, show what damage can result from sudden drying. The crate containing the mask was delivered by a transport company on a weekend and left standing for two days next to the central heating radiators.

Consistently high humidity activates fungus growth for example on animal skins and distemper bases. It can also cause corrosion on metal objects and salt efflorescence on porous ceramics.

For reasons of finance and particularly of space and execution, there is no possibility of installing air conditioning in our building. What then might be done to keep the atmosphere in the museum at a relatively "harmless" level? We try to keep an average level of humidity between 55 and 65 per cent at 20°C by using portable humidifiers and dehumidifiers. Property in the store rooms is arranged according to regional aspects. Separation according to different classes of materials would be much more favourable for the regulation of respective environmental conditions (humidity). All rooms of the museum are centrally heated so there is a guarantee that the temperature does not fall much below 20°C.

Direct and indirect sunlight(3) - because of the energy it contains (photons) - can also harm organic materials such as dyes, textiles, paper, glue and varnish. Such damage is more probably and greater the shorter the light waves are, in other words the more intensive the light is. Decomposition of this type is slow but steady and irreversible.

In order to avoid damage by light we try to shut out the ultra-violet rays as much as possible and to keep the light at a low level, in any case below 50 Lux(4). Light sensitive

materials are in glass cases of several millimeters thickness. The danger of light damage is minimal in the store rooms, which in most cases can be only lighted artifically. Light sensitive materials are best stored here in cupboards and drawers. Still in an experimental stage is an UV varnish which provides a good UV absorbing affect when applied to glass. Light bulbs and fluorescent tubes (type "warm-white delux") supply artificial illumination. It should be noted that irreparable damage can arise from strong light exposure of even short duration in photographing objects which are very light sensitive.

Damage to objects through too compact storage should be avoided. Of great help here are box-like, sliding wall cupboards(5), which are also good space-savers. Objects in the store rooms should be covered to protect them from dust and dirt. We have also experienced that it is better not to leave weapons in their cases. Even after thorough restoration corrosion can take place after the weapons are returned to their cases.

IV. Fumigation

All objects acquired by the museum which are susceptible to insects should be fumigated upon arrival before they come in contact with other pieces and before they are added to the inventory. This is a routine precaution to prevent possible spread of infection(6). At present we are still using carbon disulphide which, however, will soon be replaced by the more effective ethylene oxide(7). We also have access to the hydrogen cyanide and methyl bromide(8) fumigation systems of the Federal Monuments Office (Bundesdenkmalamt) and the Museum for Natural History.

It is also important to take preventive measures against insect attacks. The entire collection is regularly checked for insects. Furthermore, it is the duty of every staff member

to report immediately any signs of insects so that a fumigation can be carried out before they spread.

Besides taking immediate measures in the case of a serious attack by insects, it is also necessary to take in advance preventive measures towards lasting protection(9). In this connexion Xylamon, and as A. Werner(10) reports, also p-dichlor benzene, benzene hexachloride, DDT, Vapona Strips give good results. That certain pests build up resistance or become immune to preparations used over a long period should not be forgotten. For good control of pests it is important to use insecticides at the most effective times (spring and early summer).

V. Methods of Treatment

In the choice of methods of treating ethnographical objects we adhere generally to the procedures suggested by Plenderleith (11) or in the publication The Conservation of Cultural Property (12) as well as by B. Muehlethaler(13), G. Matzanetz(14), etc. Not to be neglected is the conscientious study of periodicals dealing with restoration and conservation(15).

The main principle to be followed in any restoration or conservation should be to view and treat each object as an object sui generis. There can not and should not be any one method for treating everything. The question of the right method, of the special ways and means as well as of the extent of the restoration must always be asked anew. From case to case the answer is different. When necessary, methods should be modified. An example helps to explain this further.

A special problem for the curator of ethnographical collections is presented by wood carvings which carry only a lightly applied, non-adhesive paint. Colour has been applied to many wooden objects, particularly to those of Oceania and Africa, by a variety of techniques; usually ground earth pigments are

moistened with water and applied with the finger or a primitive brush. In some cases glue (i.e., of plants) has been used as a binding medium. The colour has often suffered from abrasion, flaking and dust. The conservation of such colour coatings has been an unsolved problem, whose solution is urgently needed in view of the numerous badly preserved objects of this type.

After manifold attempts, we arrived at the following process in co-operation with the Master School for Conservation and Technology of the Academy of Fine Arts(16).

Firstly, dirt and dust are removed from the object by means of a soft artist's rubber. This can also be done with small cotton swabs moistened with soap B-30. Afterwards the painted surface is consolidated with a diluted solution of gelatine-gum tragacenth and methyl-cellulose. For water repellent surfaces or very dense wood it is recommended to add a bathotonic agent to the solution. Initially the solution was applied with a fine camel-hair brush. In particularly sensitive cases, where, for example, the colour is only very lightly applied, it is better to spray on the solution.

Because of the great number of objects which had to be restored in this way, it very soon became obvious that in order to save time the spraying should be done by means of a highly efficient spray gun. To this end the methodology had to be modified(17). The three basic components of the conserving solution were kept, however, the ratio of components was somewhat changed. Furthermore, the bathotonic agent ox-gall was replaced by Nekal and a fungicidal conserving agent was added to the fixing agent mixture. The success of the restoration is shown by a ceremonial mask of the Kurumba. The right half if unrestored; the left half has been conserved. The method has another advantage as well, as described by A. Werner; namely, that it stabilizes the paint without changing its aesthetic appearance.

VI. Documentation

One principle of restoration is the keeping of sufficiently exact records. Prior to any restoration or conservation the condition of the object is recorded and if possible photographed. The conservation procedure and the materials used are noted and when necessary supplementary examinations are carried out in the laboratory. After completion the restoration is documented in a restoration report (see Appendix I).

We consider documentation an extremely important component of restoration. Through it we learn about the success or failure of a restoration. Any critique of the methods used must be based on the documentation.

VII. Security Systems

In an extreme sense of the word conservation of museum collections includes protection from burglary, robbery, fire, damage and the effects of war(18). The world-wide increase in the robbery of works of art induced us to protect our valuable, irreplaceable collection by means of technical installations to the extent allowed by finances. The possibilities of protecting cultural property in a museum from burglary and theft are varied. This applies also to their efficiency and dependability as well as to the cost.

We chose two types of safeguards against burglary(19): 1) under constant protection in specially designed alarm show cases are particularly valuable objects. Store room doors are especially vulnerable and are also permanently secured against burglary. 2) Exposed exhibition rooms are fully secured against burglary during non-visiting hours (night-time) by a completely automatic supersonic alarm system. This type of security system as opposed to infra-red rays has the advantage that flexibility in arranging exhibits is maintained. Exhibit walls, cases, etc., do not get in the way when reorganizing displays as does the

pencil of rays of the infra-red system. The entire system is centrally regulated, coded and secured against burglary. The alarm follows accoustically (sirens) by means of a direct connexion to the central police station and by an automatically controlled telephone call to a scientific employee of the museum.

It is very important that the firm responsible for installing such a system makes periodical checks and maintenance. The capacity of an alarm system should be large enough that it can be expanded at any time.

VIII. Goals and Methods of Scientific Examinations of Ethnographic Objects

Compared to earlier times there are now numerous and varied chemical and physical methods available which can help to evaluate and describe better objects assembled by museums. In describing and classifying objects one is no longer completely dependent on the stylistic characteristics which earlier ended at a comparison of forms, figurative motif, ornaments, etc. - the so-called form and style criterion. Questions about the exact material nature of the objects, their origin and age, about the technical process of their production could only very inconclusively - if at all - be answered. However there lies latent in every object a certain measure of cultural-historical value.

With the support of other institutes the laboratory of the Ethnological Museum has been carrying out for ten years such examinations on ethnographic objects. In other countries large examination institutes which serve this purpose have existed for some time.

What goals do we have in mind in examining ethnographical objects; what general rules and guidelines must be considered?

The examinations are carried out for different purposes:

1) To guarantee a sufficiently precise description of the objects in the inventory as far as condition of the materials is concerned. In most cases short tests and simple analytical methods suffice(20). In cases where our experience and equipment are not sufficient to arrive at a decision, we refer to a specialized institute.

2) A second very important reason for examinations is the appraisal of new acquisitions. This refers mainly to recognizing wrongly declared objects or even falsifications. Particularly when large sums of money are involved it is important to inspect objects thoroughly before they are bought. Of course in such cases scientific examinations gain much significance. They provide considerable guarantee but must, however, be supplemented by other methods of critical determination, for example style analysis and the study of sources and written material. The use of subject material for drawing comparisons is absolutely advisable. The success of such scientific examinations depends finally on the special case, the type of material and the problem presented.

3) Sometimes it is necessary to examine objects prior to their restoration in order to clarify serious and above all unaccountable traces of corrosion. Such examinations should show the way to a proper restoration. Which procedure is then used in the restoration usually depends on the results of such investigations. Should the object be in a very bad condition, they will determine just how thorough the restoration may be done without damaging the object. Any retouching, copying or restoration are better carried out if the characteristics and complexities of the object are known. In this way one can best indicate the most suitable and dependable

methods of restoration or work these out himself. When necessary, methods and technical materials will have to be tested for their harmlessness and suitability.

A concrete example of this type of examination: traces of unusual corrosion were found on gold-copper alloys, the so-called Tumbaga, from Central America(21). It was proved that the unusually strong corrosion which appeared in our collection in small figures from the Chirici region, were due to inner factors and had to be attributed mainly to the special gilding technique, the mise-en-colour gilding. The objects were very fragile and broken in several places. The inside had a black, porous appearance. Over the surface lay a thin gold skin.

4) Another special occasion for examination is offered by collections which contain not only the final products of indigenous peoples, but also the materials and tools used in their manufacture. Examining the raw materials and intermediary products as well as the tools can provide a valuable, scientific supplement to the material collected by the field research and to the information, names, etc., which he has obtained from the natives. Incorrect statements can be corrected. Such examinations can greatly help to better understand old techniques which have been passed on for many years. They can also differentiate in the case of complex processes between technically necessary materials and procedures and possible ingredients and manipulations whose use can only be attributed to cult beliefs or ritual practice.

Several examinations on such welcome collections could be carried out in recent years(22).

5) Last of all I would like to speak about those examinations which are of purely scientific interest and which can be considered only in close connexion with concrete ethnological problems. Intentions and statement of the problem for such examinations vary from case to case. A pre-requisite for a sufficient interpretation of the results of the analysis is however that the objects or materials to be examined are precisely documented according to source, etc. On principle we examine only objects about which we know the exact circumstances of procurement, the regional and tribal localization, the person from whom acquired and the date of acquisition and when there is moreover an expedition report or other written source giving more information and hints. The analysis of an unidentified object is worthless. Exceptions to this rule are only then permitted when a representative number of defined experiments have been made of the problem. In such cases one can also sometimes consider the analysis of a less clearly defined object if there is a reasonable chance that on the basis of preliminary work the subject can be better defined or classified or if the object is to verify uncertain statements(23).

IX. Guidelines and Principles of Examination

The value of an examination depends decidedly on the taking of samples and the analytical methods used. In taking samples strict standards must be adhered to in order that the value of an analysis is not put in question from the start(24). Concerning the analytical methods used, a detailed description must be demanded, including the size of sample used. Only in this way can a critique of the analysis results or their reproduction be made. Very much depends also on the choice of the most suitable method(25) or methods. The criteria according to which different analytic processes are chosen and used are dependent of various factors:

1) The material and type of sample (inorganic or organic; solid form, metal alloys, solution, gas, etc.);

2) Approximate composition, not only in regard to the component sought but also to impurities;

3) The presentation of the problem, the type of information desired, the required accuracy. Is, for example, only the determination of the composition desired or also an analysis of the structure of metals. Does a purely qualitative indication of the sample components with a rough assessment of size relationships suffice or does it depend on exact quantitative determination of single or all elements. Or is it to be tested for particularly significant tracer elements;

4) The desired speed for execution;

5) Destruction or preservation of the sample. Of special pertinance in work with art and cultural objects are non-destructive methods;

6) The availability and cost of equipment;

7) Personnel factors.

It might be necessary to compromise between the requirements listed above and the realizeable possibilities. For example, precision is not usually compatible with speed in an analysis. What is decisive for a given method is in many cases the personal preference of the analyst, who will choose that method with which he is most familiar. The time spent and cost of equipment are to be considered in regard to the required precision. Each method has its principal range of application and its limitations. The use of two or more independent methods tend to increase the trustworthiness of the findings. A majority of analytic methods touch on a comparison of characteristics of samples of unknown composition with the same characteristics of a specimen or series of specimens of known composition which contain the same substance which is sought in the unknown sample.

X. Examples of Analytic Work

The laboratory of the Ethnological Museum in Vienna has for ten years carried out examinations of ethnographic objects which generally were then published. Of special importance were the following:

1) Arrow poison analyses: Chemical and toxicological examinations of curare[26]. Eighty samples of old and recent curare were examined for their alkaloid content and conclusions drawn as to their regional and tribal origins. The plants used in their production could be partly reconstrued. Even 150 year old samples yielded an unweakened potency.

2) Examination of metal objects from Central and South America: Determination of the composition and the production technique of the gold appliqué of the feather headdress of the Ambras collection which is attributed to Montezuma[27]. Examination of specific gilding techniques (mise-en-colour)[28].

3) Examination of "Benin-bronze" with regard to the alloy composition and casting technique. This concerns brass founding[29].

XI. Conclusions

The work of the chemical laboratory over the past years has shown in which areas it can be of indispensable help and service to the activities of the museum. A director of a museum might abandon the creation of a laboratory because of the high costs involved in equipping and operating it. Such considerations can be refuted. The construction of a small, efficient laboratory similar to ours can be effected with relatively small expense[30]. Important is that the personnel can adjust to the various demand and that by constant personal contact with schools and other

specialized experimental and research institutes good co-operation can be attained. Experiments which demand expensive, specialized equipment can be performed by these institutes. Any expenses thus incurred can easily be carried by the museum. Should the acquisition of a very expensive special apparatus be required, its amortization must be considered and at the same time its operator arranged. Highly specialized apparatus for analysis need one or two trained operators if the tests are to be properly carried out.

If a laboratory is installed, there must be a guarantee that the financial resources for new equipment and operating costs are available. The costs for the laboratory should be separated in the budget of the museum from the other capital and procurements (i.e., purchase of new items for the collection). Otherwise, it may come to unpleasant rivalry, which usually ends in favour of new acquisitions for the collection.

In European ethnographic museums there is still much need for improvement as far as the installation of well-equipped restoration workshops and laboratories and skilled personnel are concerned. It is to be hoped that the new working group "Patrimoine ethnographique" can help to breach these shortcomings.

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Appendix I:

MUSEUM FÜR VÖLKERKUNDE, WIEN

RESTAURIERBERICHT

Auftragsgeber:

Auftragserteilung, Datum:

Objekt: Inv.Nr.: Slg.:

Besitzer:

Beschreibung des Objektes:
(ev.mit Photo)

Materialart (ev.mit Untersuchung):

Schaden:

Untersuchungen zur Schadensklärung, bzw. Schadensbehebung: